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A Study of Thumb- and Finger-Sucking in Infants

By

Mary S. Kunst

Edited by Herbert S. Conrad

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HERBERT S. CONRAD, *Editor*

A Study of Thumb- and Finger-Sucking in Infants

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A STUDY OF THUMB- AND FINGER-SUCKING IN INFANTS

I. Introduction

It is probably safe to say that no variable has been demonstrated experimentally to be a conditioner of the acquisition of the habit of thumb- or finger-sucking. Very few of the studies reported in the psychological literature are even based upon systematic observations of thumb- or finger-sucking in infants or older children. Heering (20) observed sucking in twenty-five infants from two to seventeen weeks of age with a view to discovering how early in life thumb-sucking appears as a definite habit. Sucking was observed at each age level represented.

Blatz and Ringland (5), in a study of tics in nursery and kindergarten children, found definitely more thumb- and finger-sucking during the enforced rest period than during indoor group or circle activities, and more during the latter period than during free play indoors.

Koch (26) also found a tendency for nursery school children to display more movement mannerisms during controlled play indoors than during free play indoors, and more during the latter period than during free play outdoors. This relationship was true for other classes of mannerisms as well as for oral habits.

Levy (32) reports that hens develop head-shaking tics when movement is restrained by limiting the size of the cage. He suggests also that frustration of movement in young infants, imposed by confinement to cribs and play pens, or mechanical restraints used to prevent finger-sucking, may give rise to hyperactivity and stereotyped movements.

In spite of the scarcity of objective studies of the habit of thumb-sucking, especially in infants, many theories as to cause have been suggested. Nervousness, fatigue, local irritation on fingers or in mouth, boredom or lack of vigorous occupation, imitation and suggestion, and unhappiness have been mentioned as contributing factors but have not been systematically investigated. Among the more widely accepted theories is that advanced by David Levy (29) who, on the basis of clinical information rather than systematic observation of children, arrived at the view that children who sucked their fingers or thumbs were those who, as infants, had been deprived of opportunity for sufficient lip exercise. As evidence for this view Levy cites the facts that the incidence of thumb-sucking was higher among infants who (*a*) had been on a four-hour feeding schedule as opposed to one of three hours or less; (*b*) had been forced regularly to withdraw from the breast or bottle after a specific interval of feeding; (*c*) had had no night feedings; (*d*) had sucked from a too rapidly flowing breast or bottle.

In further support of his hypothesis Levy (30) offered evidence suggesting (*a*) that young dogs who were given insufficient sucking practice at the time of feeding were inclined to develop habits of sucking and licking their own bodies, or the bodies of other dogs, as well as other objects; and (*b*) that chicks raised on a wire floor and prevented from normal scratching activities tended to develop habits of pecking feathers from the bodies of other chicks and of pecking on the wall of the cage (31).

We may question the legitimacy of making too close an analogy between such licking and pecking activities and the finger-sucking habit of young infants,

but even if we assume the relationships Levy reports concerning infants as readily verifiable, it is conceivable that they can be more satisfactorily explained in terms other than he suggests, i.e. in terms of the effects of hunger, for example, and whatever lies back of this in the way of physico-chemical and/or tension-producing mechanisms. Not only can the four conditions favoring sucking mentioned above be accounted for readily in terms of hunger differences but this explanation is congruent also with Olson's observation of some relationships between oral habits and nutritional status. Observing many short samples of the behavior of children between ten and twelve years of age and defining an oral habit as any penetration of the mouth by thumb or finger, Olson (37) noted a tendency for extremely underweight children to show "oral habits" more frequently than children of normal weight. Even his finding that extremely overweight children tended to suck more is not incompatible with the "hunger" hypothesis, for the very weight of these children may reflect ravenous appetites. Individual differences in this regard and/or in metabolic rate, carbohydrate metabolism, or gastro-intestinal motility tend to be ignored in the traditional feeding schedules of infants.

Also ignored are the individual differences in ability to tolerate the frustration of hunger. Marquis (35) cites evidence to show that hunger is tension-producing. Babies on a four-hour feeding schedule were more active and cried more between feedings than did infants on a three-hour schedule. Moreover, when infants were shifted from a three-hour to a four-hour interfeeding period, their activity increased tremendously between the third and fourth hours. Not only were these infants more active during this hour of additional fasting, but they were also more active during the *entire* interfeeding period subsequent to the shift to a four-hour schedule than at any time during the three-hour regimen. Ribble (39), too, reports that infants on a three-hour feeding schedule were much less restless than those fed less often, even though both received an identical amount of food. These findings show objectively what we naturally assume—that infants experience tension or discomfort of some sort during hunger. It may be that infants acquire the habit of non-feeding sucking, not in response to any factor so specific as insufficient sucking practice or hunger pangs, but rather as a generalized response to tension or discomfort, physical or emotional, stemming from a possible variety of sources.

Recognizing the possibility that the sucking habit may develop as an attempt to satisfy any one of a number of needs, we nevertheless have narrowed this study to an investigation primarily of the relationship of non-nutritional sucking to hunger. It is not within the scope of the present study to explore the complex psychosomatic interrelation between emotional need and augmented hunger.

Several other experimenters not directly concerned with the problem of the relation between sucking and hunger have nevertheless made observations which seem also to lend some support to the hypothesis that sucking is related to hunger. Jensen (23), when studying differential sucking responses to taste and temperature and using as a measure of the strength of the sucking reflex the pressure applied to a nipple placed in the baby's mouth, noted that the most vigorous and long-continued sucking was done by awake babies at times when

they were probably hungry. Halverson (19), under similar conditions, found that the strength of the sucking response was greatest at the beginning of the feeding period and diminished gradually as feeding progressed.

Gesell (16) likewise has observed that "finger sucking may be prominent during the first few weeks of life, especially when the infant is hungry." Watson (49) comments that while, when one touches lightly with the finger the cheek or chin of a newborn infant, the infant tends to move the head to bring his mouth into contact with the finger, this response does not appear during sleep and very seldom immediately after feeding, but is extremely easy to elicit at later intervals after the meal.

Mead (36), who reports that primitive children in New Guinea do not suck their thumbs or fingers, observed also that children there are nursed until three or four years of age, and are usually given the breast whenever they cry or ask for it. Although Dennis (12) found the sucking habit to exist among Hopi children who also are nursed frequently, he noted a virtual absence of the habit in children of the first two years of life.

These reports, and comments to the author by the mothers of several thumb-sucking babies that the babies were always hungry, suggest that hunger may be at least one of the factors conditioning the acquisition of the habit of thumb- or finger-sucking, especially in infants. It has been established that there are individual differences in the rate of gastrointestinal motility (8, 40, 47). Back of these of course lie such other mechanisms as differences in metabolic rate, hypothalamic activity, and relationships between adrenergic and cholinergic processes. One individual may experience hunger sooner than another, even though both have eaten the same kind of food in the same amount.

Along with an increasing appreciation of the very complex nature of the gastric contraction mechanism and its conditioners has come a realization that something further is necessary to account for the experience of hunger. The early investigators (7, 8) as well as many present-day physiologists have described hunger primarily in terms of sensations accompanying contractions of the empty stomach. While there is ample evidence that a specific sensation tends to be reported by adult human subjects simultaneously with the occurrence of a certain type of graphic record secured by measuring the amount of pressure exerted upon an inflated balloon in the stomach, it appears that there is by no means a perfect correlation between even these two phenomena (6, 10, 22, 34). A subject suffering from starvation or from mild fever may experience the sensation of hunger less and less while the stomach contractions are increasing in frequency and intensity (8). There is also evidence that under more normal conditions the so-called "hunger contractions" may be recorded kymographically when the subject reports no feeling of hunger, and conversely, the subject may report a sensation of hunger when no such stomach contractions are recorded (10). Furthermore, there is ample evidence that animals deprived of somatic, cutaneous and visceral sensation will continue to eat, in some cases even when an obstacle must be overcome before food is reached. To explain this result with rats that underwent sectioning of the vagus nerves and alcoholic block of the splanchnics, Bash (1) suggests that while the stomach contractions may be the chief stimulus to

food-getting in the mature organism, the new-born reacts by aid of a chemical mechanism with swallowing and continued food-taking movements to food placed in the mouth; that this more simple, automatic mechanism is later supplemented and largely replaced by the "vago-gastric neuro sensory mechanism"; but that when the latter mechanism is destroyed by operation, the animal returns to the more primitive response. Thus chemical control of overt response to gastric motility and to food is differentiated from chemical control of mere gastric motility.

Tsang (48) demonstrated the presence of the hunger drive in rats that lacked the contractile stomach tissue. Rats in which the major part of the stomach was removed, leaving only a narrow passage slightly wider than the duodenum, were nevertheless practically as well motivated to run the maze after a twenty-four hour fast as were normal animals.

On the one hand, then, we have the explanation that the sensory excitation giving rise to a feeling of hunger is due directly to the contractions of the stomach, or possibly to contractions of the esophagus, duodenum, or intestines. On the other hand, it has been suggested that some agent, possibly chemical in nature, acts directly upon the central nervous system to arouse a craving for food. One mechanism suggested is that of diminishing food reserves in the blood which act in some way directly upon the brain and give rise to consciousness of hunger. Such central theories to account for the sensation of hunger were suggested also many years ago, but lack of convincing evidence has led physiologists, rightly or wrongly, to emphasize the role of gastro-intestinal motility in bringing about the sensation of hunger. A main objection to central explanations involving a chemical mediator has been that food cannot be assimilated fast enough to account for the immediate feeling of satiety upon partaking of food. Yet it appears that products of digestion may have rather immediate effects upon the blood. It has been demonstrated (1) that injection of blood from starving dogs into normal dogs which are having moderate stomach contractions will almost immediately be followed by an increase in gastric tonus and in stomach motility in the normal dogs. And conversely, transfusion of blood from a recently fed animal to one that has been starved eighteen to twenty-four hours will be followed by an inhibition of contractions in the starved dog (1). Likewise, if the blood sugar level is lowered by about twenty-five per cent, stomach contractions increase in frequency and intensity, but promptly subside if sugar is injected. Furthermore, emotional stress may produce a gastric pattern of functioning very similar to that which obtains during periods of abstinence from food (51).

It seems that however important the contractions of the empty stomach are for mediating the feeling of hunger, we cannot exclude at least as tension-producing, other factors—possibly chemical in origin—that might be due to more subtle effects of depletion of stored nourishment in the body.

Recent work on the functioning of the autonomic nervous system clarifies our understanding of gastrointestinal mechanisms. The complex functional interrelationships among the autonomic, somatic, and endocrine systems suggest that hunger may be initiated intra-organically or centrally. It was found (24), for example, that electrical stimulation of

the lateral hypothalamic area in cats was followed immediately by inhibition of peristalsis and loss of muscle tonus of the stomach. Since the hypothalamus is so complexly integrated with all body functions (15), it follows that hunger may be sensitive to a wide variety of complex factors.

On the question of the part specific food deficiencies play in arousing hunger or at least tensions, the literature offers not too much, though our information is increasing rapidly. Hoelzel and Kleitman (22), on the basis of experimentation on one individual, suggest that the gastric contractions may simultaneously give rise to a specific and a non-specific hunger sensation. They offer some evidence that the ordinary contractions in this subject might have reflected a carbohydrate and caloric need, while a certain type of hunger sensation, which did not always parallel the gastric contraction and which was accompanied by increased respiration, might have been due to protein starvation.

Richter has been interested in the role of specific food deficiencies in appetite and has contributed many enlightening studies on the rat's ability to discriminate and choose a needed food element. For example, Richter, Holt, and Barelare (43) demonstrated that rats deficient in vitamin B were able to discriminate immediately a water solution containing this vitamin from twelve other foods and solutions, and after tasting the vitamin B solution the rats fiercely resisted removal of the bottles containing it. Richter states, "The fact that the animals showed an immediate liking for the vitamin indicates that the appetite may not depend entirely on the experience of a beneficial effect resulting from the ingestion of the vitamin."

Richter and Campbell (42) found that rats were able to distinguish between distilled water and certain sugar solutions and preferred the latter in the following order: maltose, glucose and sucrose, galactose. Lactose was chosen scarcely at all. The authors cite evidence suggesting that maltose may be utilized directly without being broken down into glucose. Also, a test of the effectiveness of four sugars for survival of rats when they had no other food indicated that glucose was most adequate for survival, that sucrose was almost as effective, but that lactose and galactose were very inadequate for the maintenance of life.

Richter (41) has shown also how appetite for salt is at least in part dependent upon the functional state of the adrenal glands. Rats ordinarily die within a few days after being subjected to adrenalectomy, but if following the operation the animals are given a free choice between ordinary tap water and water containing a three per cent salt solution, they will choose the salt water in preference to the tap water to an extent sufficient to increase greatly their survival rate.

Wilkins and Richter (50) report the history of a three-and-a-half-year old boy who died suddenly when limited to a regular hospital ward diet. Investigation brought to light not only defective adrenal cortical tissue, but also the fact that the boy had been experiencing an increased appetite for salt and had satisfied it to a degree sufficient to keep himself alive. The parents reported that the boy had shown a great craving for salt from the time he was eleven months old.

Evidence such as we have cited leaves no doubt that specific food deficiencies are an important determiner of "hunger," or appetite. It is likely that much

further work is needed to clarify the mechanism involved. Young (52, 53) believes that food is rejected or accepted in part on the basis of "need"; that an organism's response to food is mediated through the gustatory and olfactory senses and is in the nature of a "chemotropism." Young suggests that the chemical state of the olfactory and gustatory cells is an index of the chemical state of the entire organism and an animal chooses or rejects specific foods in part in accordance with its chemical state of the moment.

Rather similar to this explanation of the hunger drive is the avidity theory of Katz (25) who attributes an animal's acceptance or rejection of food "to the fact that the organism is adapted to certain substances which are able to maintain the chemical equilibrium, or to restore it if it has been disturbed." Katz makes it clear that the discrimination of the needed food is not dependent on experience for its development, as it may function when the animal is first exposed to a specific food. Moreover, Katz cites many interesting examples of animal behavior which show clearly the futility of trying to account for food intake exclusively in terms of one physiological mechanism. He shows, for example, how the quantity of food consumed may depend upon external factors such as the social situation confronting the animal, or how native preference for a specific kind of food may change entirely following the introduction of an external influence which disturbs the organisms' chemistry. For example, caterpillars that customarily feed on oak leaves were placed on pine trees. The next generation of the caterpillars that managed to survive preferred the pine needles to oak leaves as food.

Since it is clear that the nature of the tensions generated by food-lacks is none too well understood, we cannot hope at this time to develop a comprehensive measure of these tensions. This drawback, however, by no means prevents us from making a pertinent contribution to the problem of the relation between sucking and hunger which, whatever its nature, must result when food is withheld. Because we lack techniques to measure all components of hunger we have more or less confined the present study to what might be thought of as the gastric contraction aspect of hunger. And though we do not measure even the hunger contractions directly, the variables upon which they depend are so well established that we feel safe in using a more indirect approach. We had hoped at first to gauge individual differences in hunger contractions directly in order to determine whether the infants with the more vigorous gastro-intestinal activity were those most prone to the development of thumb-sucking. The practical difficulties involved in measuring hunger contractions in infants, however, led us away from a direct attack on the problem of individual differences to a consideration of the relation between the frequency of thumb-sucking in infants generally and the length of the interval since last feeding. The greater the interval after feeding the safer it seems to assume hunger present in a group of babies. Since the time at which hunger contractions appear after feeding is a function of both the kind of food and the amount of food eaten, we have attempted an exploration of the relation of these two latter factors to frequency of sucking in a group of infants.

As an outgrowth of our interest in the problem of the relation between hunger

and sucking, our attention became fixed also on other variables.

Let us summarize here the questions we asked ourselves.

1. Is the amount of non-feeding sucking observed in infants a function of the length of time elapsing since the last meal?

2. Are differences in non-feeding sucking related to differences in the amount of formula prescribed?

3. Do infants tend to suck their fingers and other objects more at stated times following a meal of one composition than following meals of other compositions?

4. Are there individuals whose non-feeding sucking practices differ radically in pattern from that of the group?

5. Are there any characteristic age and sex trends in non-feeding sucking?

6. Do infants who are teething tend to suck their fingers, hands, tongues, and other objects more than infants of the same age who are not yet teething?

7. Do infants tend to suck their fingers more frequently during the waking state?

8. Does non-feeding sucking vary with the number of attendants in the room?

9. Is the frequency of non-feeding sucking while the infants are alone in their cribs any greater than when the children are in more stimulating situations, such as on the floor with other infants, or in chairs and walkers?

10. Is the body position the infant assumes a determiner of the likelihood he will indulge in sucking his thumb?

In order to avoid repetition let it be understood that from this point on, when we use the term sucking, we shall mean non-feeding sucking, unless otherwise specified.

II. Method

A. The observation situation

This study was made in St. Vincent's Infant and Maternity Hospital, one of the largest orphanages in Chicago. Among the infants cared for, a few are born in the institution. Some are orphans, or waifs of unknown parentage. Other infants are placed in the temporary care of the institution during illness of the mother, during periods of severe economic stress in the family, or in the case of some family upheaval. The time spent in the institution by any one child may vary from a few days to five years, but very few children remain more than a year or two.

Practically all infants we studied were on a so-called four-hour feeding schedule, the first feeding in a day being offered at approximately 6:00 A.M. However, when the babies were three months of age it was customary to introduce cereal into the diet and this cereal was usually fed to the children between 7:30 and 8:30 A.M. A vegetable meal was added when the babies were three and one-half months of age and was served as near noon as possible. Hence the period between feedings in the morning for the group of infants three and a half to seven months of age was considerably less than four hours. In fact it was more nearly a two hour period.

By the time the infant reached seven to eight months of age, he was weaned from the bottle and put on a three-meal-a-day schedule. The first meal was given between 7:00 and 8:30 A.M. and consisted of cooked cereal, and milk served in a cup. When the babies were about nine months of age, an egg was added to this meal. The vegetable meal was offered around noon and included mashed potatoes, a puréed vegetable, and milk served in a cup. Ground meat was added to this meal after the babies reached one year of age. The third meal was served between 4:00 and 5:30 P.M. and consisted of pudding, fruit, and a cup of milk.

It should be stated that, in addition, cod liver oil and orange juice were given the children throughout this regimen, the former being included in the diet after the babies were two weeks old and the latter from twelve weeks on.

B. Plan of observation

The observations reported in the present study were made on fifty-two days scattered between July 15 and December

TABLE 1

Age Levels at Which Members of Various Age Groups Served as Subjects

Age in Weeks at Which Children *First* Served as Subjects	Age of Subjects in Weeks													
	1–4		5–8		9–12		13–16		17–20		21–24		25–28	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1– 4	17	100.0	13	38.2	8	21.6	4	8.3	1	2.0	1	1.9	0	0.0
5– 8			21	61.7	14	37.8	9	18.7	6	12.2	5	9.4	4	9.1
9–12					15	40.5	13	27.1	8	16.3	6	11.3	4	9.1
13–16							22	45.8	15	30.6	12	22.6	9	20.5
17–20									19	38.8	14	26.4	12	27.3
21–24											15	28.3	9	20.5
25–28													6	13.6
Total	17	100.0	34	100.0	37	100.0	48	100.0	49	100.0	53	100.0	44	100.0

(Continued on page 9)

22, 1937. Observations made for a month and a half preceding this period were considered part of a preliminary study emphasizing technique and, with one minor exception, are not reported here. Our subjects were infants from birth to a year of age. We should have liked to study older children also, but time limits forced us to restrict the age range to be studied. A total of 28,000 samples of behavior of a total of 143 different children were described.

A longitudinal approach with observation of a constant group of subjects at successive ages is ideal for throwing light upon the age variable in relation to sucking. This method it was possible to use only to a limited extent, for only a few children remained in the institution throughout the period of our observations. In Table 1 we have made some attempt to acquaint the reader with the extent to which our method might be considered a longitudinal one as the table indicates the overlap in position of successive age groups. Take the five to eight weeks group as an example. Of this group of infants, thirteen or 38.2% were first observed at the one to four weeks level. Twenty-one or 61.7% were introduced as new subjects at five to eight weeks of age.

It is clear from Table 1 that there is a great deal of overlap in subjects at adjacent age levels, and even for a range of several age groups among the older infants. To protect ourselves as far as possible against selective factors dynamically related to the variables we were exploring that might arise from the introduction of new subjects at successsive age levels, we worked with sizable groups of infants at each level. Since it may be, however, that the healthier babies were adopted earlier, and that the older babies who entered the orphanage had experienced more stress relatively than the younger, the isolation of the influence of the age variable may not have been entirely successful.

The average number of children observed in a day was twenty-two. Each subject was observed during about one day a week, except the infants under twelve weeks of age who were observed during two or three days a week. We were de-

TABLE 1—(*Continued*)

Age in Weeks at Which Children *First* Served as Subjects	Age of Subjects in Weeks											
	29–32		33–36		37–40		41–44		45–48		49–52	
	N	%	N	%	N	%	N	%	N	%	N	%
1– 4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5– 8	2	4.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
9–12	5	10.9	3	9.7	2	7.7	0	0.0	0	0.0	0	0.0
13–16	5	10.9	3	9.7	2	7.7	2	8.3	0	0.0	0	0.0
17–20	12	26.1	7	22.6	3	11.5	1	4.2	1	5.3	0	0.0
21–24	7	15.2	5	16.1	2	7.7	2	8.3	0	0.0	0	0.0
25–28	5	10.9	4	12.9	4	15.4	4	16.7	3	15.8	3	21.4
29–32	10	21.7	7	22.6	7	26.9	7	29.2	7	36.8	5	35.7
33–36			2	6.4	2	7.7	1	4.2	1	5.3	0	0.0
37–40					4	15.4	3	12.5	2	10.5	2	14.3
41–44							4	16.7	2	10.5	1	7.1
45–48									3	15.8	2	14.3
49–52											1	7.1
Total	46	100.0	31	10010	26	100.0	24	100.0	19	100.0	14	100.0

sirous of making as many observations as possible during the ages when the sucking habit in the majority of our children might be beginning. A round of observations was made approximately every ten minutes of the day between 7:30 A.M. and 2:30 P.M. These hours were chosen largely on the basis of the experimenter's convenience. Moreover, inasmuch as all data relating to the feeding variables are analyzed by separate meals, it was desirable to concentrate the observations on a few meals to insure sufficient data for each meal analysis. We feel, however, that results from this particular span of observation hours yield, for our purposes, a valid index of the infants' sucking behavior, for the trends and relationships shown in the results to be presented agree closely with the results found in our preliminary study in which observations were made from 7:30 A.M. to 7:30 P.M.

C. MEASUREMENT OF THE SUCKING TENDENCY OR HABIT

1. *Definition of Non-Feeding Sucking*

Insertion of thumb, finger, or any object into the mouth was counted as sucking, provided the lips closed upon the object. If a child's finger rested on his tongue or teeth, and the mouth was open, it was not recorded as sucking. In addition to the sucking of objects, spontaneous sucking movements independent of any object on which to operate were recorded. We termed these latter activities "mouthing," and defined them as pursing and movement of the lips very similar to the feeding reaction, but with no external tactual stimulus present.

2. *Measurement of the Strength of the Tendency to Non-Feeding Sucking*

The short-behavior-sample technique was used to measure the strength of the sucking tendency. Observations of behavior relative to sucking were made during many brief intervals of time. During each observation it was noted whether or not the child was sucking, as well as the type he was indulging in. A child's "sucking" score for the day was the proportion of the total number of observation units for the day in which he was seen to be sucking. In addition to these items, notations were made for each sample of behavior in regard to whether the baby was sleeping or crying, whether or not he was in bed, his body position, and the number of attendants in the room. The number of attendants present and the body position of the infant were recorded for only a part of the study.

When ready to record the sucking behavior, the observer entered the ward and took a position from which the first child could be viewed. She looked down at her record blank, then cast a brief glance at the child, then recorded a description of the behavior. She next cast a brief glance at the second child and recorded his behavior, and so on. The moment chosen for observation was always the first one after completing the record of the previous child. Every child in a ward was used as a subject, and the subjects were observed in accordance with a definite rotation scheme in order to avoid any bias.

No observations were made of a child when it was being held by a nurse, or was in the process of being bathed or fed or changed, or was undergoing a medical examination, for it was felt that such situations necessarily influenced the spontaneous activity of the child. If a child could not be observed when it came his turn, no return was made to him until the appropriate time in the next round of observations. During all observations, then, the infant was in his bed, or in a chair or walker, or on the floor, and was having no physical contact with an adult.

III. Reliability of Indices

A. Observer Accuracy and Consistency

The experimenter and another trained psychologist simultaneously observed and described the same phenomena on five different days throughout both the preliminary and the main study. Both observers glanced at the subject and then promptly recorded their descriptions of the child independently on a record blank. Extent of agreement with respect to each category in terms of which the child's behavior and the situation were to be described is set forth in Table 2.

The high percentages of agreement shown in Table 2 seem to suggest that the experimenter tended to record consistently and that her interpretation of the items classifiable in each category was reasonable.

B. Instrument Reliability

To get some light on the question of reliability of measurement, we computed correlations between scores based on alternate observation periods. Of course a measure yielding a low reliability coefficient may be a very accurate measure of a very variable trait. Hence, assuming a dependable observer, we tried to view the reliability coefficients more as indicators of the stability of the habit of sucking rather than as indicators of the excellence of the measure.

The reliability coefficients obtained are listed in Table 3. A separate coefficient was calculated first for the data of each four-week group, to correspond to the manner in which the data are grouped for the various analyses. For purposes of measuring reliability and for all the analyses of variables by age, each child has been given one sucking score for each week he was observed. Hence he was entered as four separate cases in a given alternate item correlation if he was observed each week of the four weeks in-

TABLE 2

Agreement Between Observers

Item Observed Simultaneously by Two Observers	Date of Simultaneous Observation				
	June 16	June 21	July 6	Sept. 24	Dec. 10
	Percentage of Agreement				
Sucking	100.0	100.0	99.5	99.6	99.4
Mouthing	100.0	100.0	98.9	99.1	98.3
Sleeping	91.3	95.9	96.2	96.9	98.9
Crying	97.1	99.3	99.5	100.0	99.4
Number of attendants present	98.1	96.6	96.2	96.4	....
Body position of infant	....	....	....	....	92.8
Location	....	98.0	....	100.0	....
	Absolute Counts				
Total number of observations	103	148	185	224	181
Instances of sucking agreed upon by observers	28	28	33	54	43
Number of different subjects observed	35	63	66	38	31

TABLE 3

RELIABILITY COEFFICIENTS OF MEASURES OF SUCKING TENDENCY

Age of Subjects in Weeks	Correlation between Scores Based on Alternate Observations of Sucking Behavior	Correlations after Spearman-Brown Correction	Number of Weekly Records
Unit of Measurement = one pair of sucking scores (for odd- and even-numbered items) for each child each week			
1– 4	+.70±.09	+.82±.06	35
5– 8	+.79±.04	+.88±.03	92
9–12	+.75±.05	+.86±.03	90
13–16	+.81±.04	+.90±.02	87
17–20	+.68±.05	+.81±.04	106
21–24	+.63±.06	+.77±.04	113
25–28	+.74±.05	+.85±.03	94
29–32	+.72±.05	+.84±.03	96
33–36	+.67±.06	+.80±.05	72
37–40	+.69±.07	+.82±.05	61
41–44	+.75±.06	+.86±.04	58
45–48	+.73±.06	+.84±.04	55
49–52	+.66±.11	+.80±.08	27
5	+.73±.10	+.84±.06	22
7	+.81±.07	+.90±.04	22
14	+.90±.04	+.95±.02	24
16	+.65±.12	+.79±.08	24
23	+.76±.08	+.86±.05	26
24	+.55±.14	+.71±.10	27
45	+.82±.09	+.90±.05	15
48	+.58±.19	+.73±.14	12
Unit of Measurement = one pair of sucking scores for each child for each four-week period			
			Monthly Records
5– 8	+.84±.05	+.91±.03	34
13–16	+.80±.05	+.89±.03	48
21–24	+.75±.06	+.86±.04	53
45–48	+.90±.04	+.95±.02	19

cluded in the correlation. To illustrate, John's sucking score was 5/22 on Monday and 6/28 on Wednesday of his eleventh week of life. His sucking score for that week is 11/50 or 22 per cent. Separated into two alternate item scores, the odd score is 6/25 or 24 per cent, and the even score 5/25 or 20 per cent. These two points are plotted as those of this subject in the scatter diagram for the nine- to twelve-week group. If this same child had an odd score of 25 per cent and an even score of 30 per cent for the twelfth week, these two variables were plotted as if for a second subject in the same age group. Thus some subjects may have only one pair of variables for a given correlation, while other infants may have two, three or four pairs of sucking scores for a given reliability coefficient.

Recognizing the possibility that our unit of measurement and the use of several different scores for the same individual might make the so-called reliability coefficients spuriously high, we have included in Table 3 a few additional reliability coefficients based on somewhat different units for our variables. To avoid

distortion because of the last named consideration and to provide a coefficient for a score unit we shall use most frequently in our comparisons, we computed correlations in which the scores correlated were those obtained within a single week. The weeks arbitrarily chosen as samples are indicated in Table 3, lines 14 to 21. It will be noted in each sample that an average of the two weekly coefficients very closely approximates the coefficient of the four-weeks group of which the weekly data are a part.

Again allowing each subject to influence the correlation equally, but using the scores for a four-week period, since this period is used frequently in our comparisons, we computed the coefficients which appear in the lowest section of the table. For each child a monthly score was computed for all the odd-numbered and all the even-numbered observations for the four-week period.

It is seen that despite the markedly reduced number of cases, these latter coefficients are practically the same as or higher than their corresponding coefficients in which each child's weekly score was used as a unit of measurement. This is to be expected since it is obvious that the greater the number of observations made of a child the greater would be the likelihood that the scores based on odd- and even-numbered observations would be similar, i.e., that the role of incidental variables would be discounted.

The size of the reliability coefficients presented in Table 3, as well as the agreement of the results based upon various units of measurement, suggests a fairly high degree of consistency, at least over small units of time, in the sucking habit of young infants. We felt that it was entirely justifiable to base our various analyses of the sucking habit of young infants upon weekly scores. This seemed desirable because of the shifting nature of our groups.

IV. Results

Because of our inability to procure direct measures of hunger in the individual infant, as we have explained in the Introduction, we approached the problem of the relation between hunger and sucking by studying the effect of certain variables known to influence hunger upon the average sucking frequency of groups of infants. This indirect approach, however, confines us to the problem of whether infants suck while they are hungry, and prevents us from generalizing concerning the very crucial question of whether the particular infant on the same diet and schedule as others but with more vigorous and frequent "hunger" contractions is the one more apt to acquire the sucking habit.

The variables known to influence hunger which were related to sucking habits in this study are: (1) the length of time elapsing since the last meal, (2) the amount of food eaten, and (3) the kind of food eaten.

A. The Relation Between Frequency of Sucking and the Time Elapsing Between the Observation Period and the Hour of the Last Feeding

Since gastro-intestinal motility is known to be influenced by a variety of factors, we would not feel safe in assuming the existence of hunger in an individual child at any particular time. But it has been established repeatedly that hunger contractions tend to begin a certain time after a meal, and increase in frequency and intensity with each recurring cycle until food is again supplied. Individual differences in the vigor or the frequency of hunger contractions, as well as the latter's timing relative to meals, are known to exist, but the average time required in young infants for the appearance of "hunger" contractions after a meal has been found to be between two-and-a-half and three-and-a-half hours, the interval being shorter usually for younger infants (18, 27, 47). It seems entirely justifiable to assume that hunger in a group of subjects is likely to increase as the time since the last feeding increases. Hence, if we find the frequency of sucking increasing consistently as the interval from the last feeding increases, and markedly around two to three hours after the last meal, we shall be inclined to assume, unless the evidence is clear that other variables are influencing the picture, that hunger has some effect upon sucking.

1. *The Occurrence of Sucking and Other Variables in Relation to Fasting Interval*

Since we recorded the time for each child when meals were eaten and the time from specific meals of each short sample of behavior observed, it was possible to chart frequency of sucking as a function of length of time elapsing since a meal. But before conclusions can be drawn concerning the influence of length of fasting interval upon sucking we must endeavor to know what other factors known to influence sucking are varying also with this fasting interval. We will show presently how our data establish relationships between sucking behavior and variables such as the crying, the sleeping, the location, and the position of the infant as well as the presence of attendants in the ward. In Figures 1 to 13 we present the frequency with which these items as well as sucking behavior were observed in successive ten-minute intervals after specific meals. We com-

TABLE 4

FREQUENCY OF OBSERVATION OF INFANTS AT EACH TEN-MINUTE INTERVAL FOLLOWING THE 6:00 A.M. FORMULA MEAL

Ten-Minute Interval after the Meal	Age of Infants in Weeks			
	1–4	5–8	9–12	13–16
	Number of Times Observed			
13	..	36	...	..
14	..	39	...	..
15	.	62	34	..
16	..	63	37	..
17	20	89	61	..
18	23	75	83	..
19	31	98	82	..
20	43	110	100	23
21	44	139	114	23
22	50	130	114	34
23	58	153	121	26
24	51	138	116	32
25	54	125	118	24
26	46	143	129	38
27	38	135	106	29
28	23	104	86	23
29	23	82	60	..
30	..	53	57	..
31	..	31	23	..
32	..	23	...	..

puted for each item the percentage of the total observations at each interval subsequent to the meal in which it occurred. Tables 4 to 7 show the number of observations made at each ten-minute interval. The data for each age group as well as for each meal are treated separately because we felt that different constellations of factors were at work in these cases. The number of observations determining each point in the curves of sucking, sleeping, crying, and being out of bed are always identical because notations on each of these items were made for each sample of behavior. Notations on the presence or absence of attendants were made during only approximately half the term of the study and the number of observations determining a point is consequently about half that for the points on the sucking curve at any given interval. "F 6" refers to the 6:00 A.M. formula feeding and "F 10" refers to the

TABLE 5

FREQUENCY OF OBSERVATION OF INFANTS AT EACH TEN-MINUTE INTERVAL FOLLOWING THE 10:00 A.M. FORMULA MEAL

Ten-Minute Interval after the Meal	Age of Infants in Weeks									
	1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40
	Number of Times Observed									
1	71	199	154	106	129	133	105	100	73	49
2	54	162	140	83	97	123	93	83	62	44
3	48	146	120	76	86	90	84	77	59	36
4	50	138	119	75	76	83	77	84	59	33
5	50	136	116	59	80	86	72	71	43	35
6	46	122	107	62	60	69	63	59	30	27
7	35	111	106	53	51	75	54	61	40	22
8	35	122	96	59	48	69	49	50	37	26
9	34	110	87	52	27	55	43	42	32	22
10	28	133	99	57	30	46	46	47	34	25
11	40	129	101	46	21	42	41	41	32	20
12	46	131	101	48	...	34	42	32	23	23
13	39	133	97	44	...	...	28	30	21	..
14	34	114	88	35	...	..	...	...	..	..
15	31	108	85	30	...	...	...	...	..	..
16	35	101	74	24	...	...	...	...	..	.
17	28	81	58	21	...	...	...	...	..	.
18	22	59	47	...	...	...	...	.	.	..
19	..	35	37	...	...	...	...	.	.	..
20	..	26	...	...	...	...	...	...	..	..

TABLE 6

FREQUENCY OF OBSERVATION OF INFANTS AT EACH TEN-MINUTE INTERVAL FOLLOWING THE CEREAL MEAL

Ten-Minute Interval after the Meal	Age of Infants in Weeks									
	13–16	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52
	Number of Times Observed									
1	..	..	36	22	21	25	..	..	21	..
2	..	..	40	26	23	27	..	..	21	..
3	..	33	51	39	26	24	23	..	27	..
4	..	43	55	46	30	24	24	..	31	..
5	27	64	69	49	34	28	24	..	30	22
6	33	69	73	59	44	40	33	26	37	25
7	28	67	64	59	53	36	32	32	38	21
8	41	88	95	79	66	50	31	29	32	23
9	39	79	94	80	68	56	41	38	41	22
10	40	86	90	72	79	57	37	38	43	20
11	44	93	90	75	69	60	39	38	44	21
12	44	85	76	70	77	63	51	42	45	23
13	52	96	93	69	76	61	45	48	49	21
14	51	93	74	56	62	50	38	43	50	24
15	52	69	59	59	53	41	33	47	45	25
16	43	50	38	39	38	27	27	34	45	24
17	36	44	26	22	24	..	21	32	47	26
18	25	29	..	..	..	..	..	39	47	22
19	..	20	..	..	..	..	..	36	39	23
20	..	..	..	..	..	..	..	32	33	20
21	..	..	..	..	..	..	..	23	38	..
22	..	..	..	..	..	..	..	20	43	..
23	..	..	..	..	..	..	..	25	36	..
24	..	..	..	..	..	..	..	26	33	..
25	..	..	..	..	..	..	..	25	30	..
26	..	..	..	..	..	..	..	25	28	..
27	..	..	..	..	..	..	..	23	25	..
28	..	..	..	..	..	..	..	..	23	..

TABLE 7

FREQUENCY OF OBSERVATION OF INFANTS AT EACH TEN-MINUTE INTERVAL FOLLOWING THE VEGETABLE MEAL

Ten-Minute Interval after the Meal	Age of Infants in Weeks								
	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52
	Number of Times Observed								
1	78	85	60	64	53	60	56	56	25
2	68	68	50	52	44	53	53	45	27
3	58	58	47	50	46	46	47	49	27
4	60	48	38	46	44	48	46	52	26
5	45	39	27	31	36	47	44	48	24
6	41	33	..	21	29	40	40	40	22
7	36	22	..	..	21	37	32	31	..
8	31	..	..	..	20	29	25	30	..
9	25	..	..	..	..	21	23	25	..
10	..	..	..	..	..	..	..	22	..

10:00 A.M. formula feeding. The top figures describe the frequency of occurrence of sucking and of presence of attendants by ten-minute intervals after the meal. The bottom figures present the incidence of sleeping, of crying, and at later ages of location, by ten-minute intervals after the meal. It will be noted that observations following the 6:00 A.M. formula meal begin as late as the thirteenth to the twentieth ten-minute interval after feeding. This is due to the fact that the experimenter did not make observations before 7:30 A.M. to 8:00 A.M., and to the tendency on the part of the attendants to administer the "six o'clock" feeding before six o'clock, in order to have all the routines connected with the meal completed in time for the change of personnel at 7:00 A.M. Furthermore, while many infants were observed at earlier intervals, no point on the sucking curve has been plotted unless it represents at least twenty observations. Having fewer than twenty observations on which to base the location of a point on the sucking curve explains also the few instances in which the curves for the period following the cereal meal begin in the third to the sixth ten-minute interval after feeding.

The head nurse of the night shift in each ward timed the beginning and ending of the early morning feeding for the group as a whole in both rooms of her ward, and fed the infants in the order of the numbers designated on their beds. From these data, the experimenter estimated the time of the early morning formula for each infant. All other timing was done by the experimenter for each child individually.

The most striking result revealed by Figures 1 to 13 is the consistent upward trend in sucking frequency as time elapses after the meal. The data for only one meal, i.e., the vegetable one at noon, seem not to exhibit this trend and in this case the time spans available for observation were very short and hunger could scarcely have exerted a substantial effect. This upward trend in sucking does not always begin immediately after the meal. At times there is a decrease in sucking during the first few intervals, or, if not a decrease, at least a plateau. But at about an hour and a half to two hours after the meal, at the time when hunger pangs are probably beginning in many of the infants, there can be seen a clear-cut and steady rise in the sucking curves which lasts until the next meal. There are few exceptions to this increase in sucking for the intervals following the ten o'clock formula and the cereal meals. One exception is noticed for our youngest age group for whom a very marked increase in crying, which may have interfered with sucking, begins at about the time after the ten o'clock formula that we expect hunger contractions to start. Crying is invariably found to be relatively infrequent during time intervals immediately subsequent to feeding for all ages, and to increase noticeably from the second hour after feeding for our three youngest age groups. In keeping with our hypothesis is a finding by Marquis (35) that infants on a four-hour feeding schedule were more active and cried more frequently and for longer duration than did infants on a three-hour schedule. Moreover, infants who were changed from a three to a four-hour schedule cried more not only during the fourth hour of fasting, but also during the entire interfeeding period subsequent to the formula change.

Attention is called to a tendency on the part of infants of the three youngest

age groups to suck relatively frequently immediately after the ten o'clock formula. This phenomenon may be due to a number of factors. As we shall explain later, young infants of these first three lunar-month groups tend to do a greater proportion of their sucking while they are awake. It must be emphasized too that these infants sleep during a very large part of the day. Since we find the maximum number of infants awake during the first few intervals immediately following the meal, we are not surprised to find fairly high proportions of sucking during these same intervals, with a decrease in frequency of sucking as more infants fall asleep. Another explanation for this initial spurt in sucking after feeding

FIG. 1. Frequency of occurrence of sucking, sleeping, crying and presence of attendants in relation to interval after feeding. Age group 1-4 weeks.

may be the preponderance at this time of the prone position in the infants, a position which we will later demonstrate facilitates sucking. A third possible explanation is the suggestion by Blanton and Blanton (3) that over-distention of the stomach gives rise to sensations akin to hunger contractions and may stimulate sucking. The same phenomenon of initial spurt in sucking is seen in certain instances after the cereal meal, but the frequencies reached are probably no higher than would be expected in fluctuation from interval to interval and do not obscure the positive correlation between sucking frequency in an interval and distance of the period in time from the meal.

Fig. 2. Frequency of occurrence of sucking, sleeping, crying and presence of attendants in relation to interval after feeding. Age group 5-8 weeks.

The consistency of the upward trends in our sucking curves for all types of meal and for all age groups, and especially in the period after one and one-half to two hours have elapsed since feeding, leads us to conclude that the longer a child has been without food the more likely he is to suck his thumb, fingers, or other objects.

2. *The Influence of Certain Environmental or Occupational Conditions upon Sucking*

a. *Sleep.*—Since degree of awareness

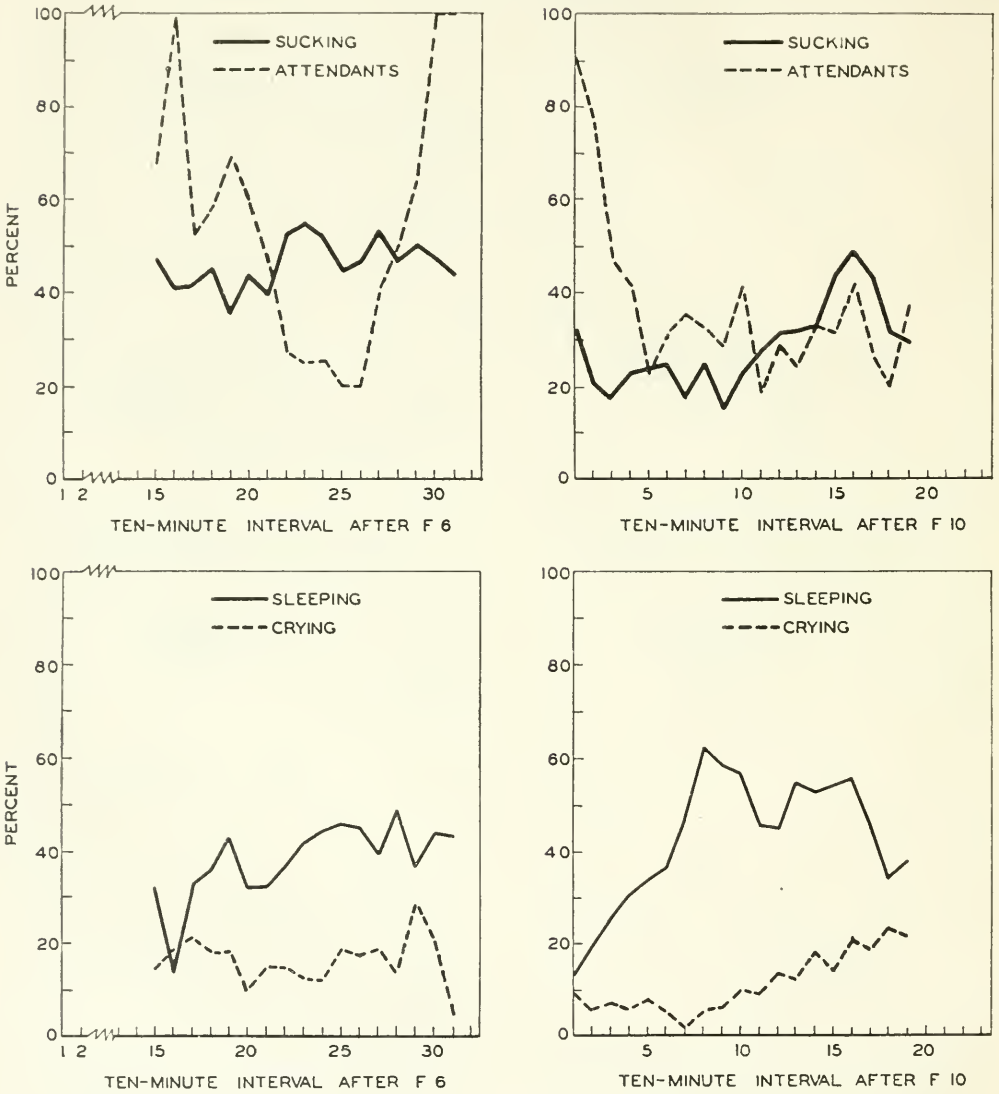

FIG. 3. Frequency of occurrence of sucking, sleeping, crying and presence of attendants in relation to interval after feeding. Age group 9-12 weeks.

and general activity is reduced during sleep and babies sleep a great deal, as well as sleep less as they grow older, it seemed well to discover what if any relation there was between sucking and sleep.

Judgments concerning whether or not our babies were asleep when observed were made by the experimenter. The criteria of sleep used were closed eyes, lack of bodily movement, and deep breathing. Sleep was often recorded when one of the three criteria failed to obtain. For instance, there were times when, although the baby's eyes were slightly open, the deep breathing and quiescence led to a judgment of sleep. Likewise, change of

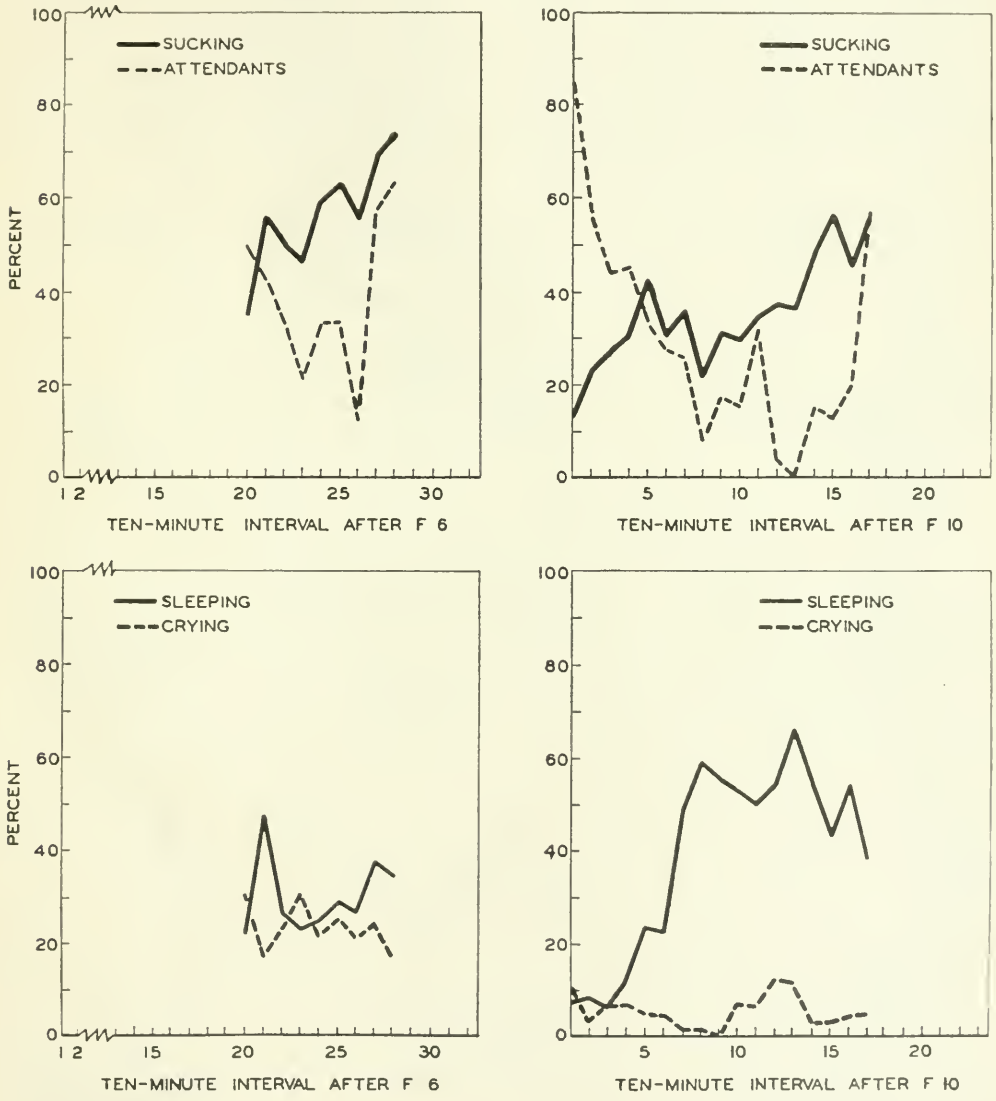

Fig. 4. Frequency of occurrence of sucking, sleeping, crying and presence of attendants in relation to interval after feeding. Age group 13-16 weeks.

position by the infant during the observation did not necessarily imply that he was awake.

Figure 14 facilitates a comparison of the frequency of sucking during sleep with the frequency during the waking state for each weekly age group. In the one curve are plotted ratios between the number of observed instances of sucking during sleep and the number of observations made while the subjects for each age group were asleep. In the other curve is plotted the proportion of instances of sucking observed while the subjects were awake to total observations made while the subjects were awake. The data are combined as though for one subject, only one score being computed at each week of age. It will be seen that infants up to sixteen weeks of age do relatively more sucking while awake, while after twenty weeks the reverse trend appears.

Table 8 indicates the sucking scores and the significance of the differences between sucking scores earned during sleep and waking by the children of each age group. The differences, as well as the critical ratios, are greatest during the first

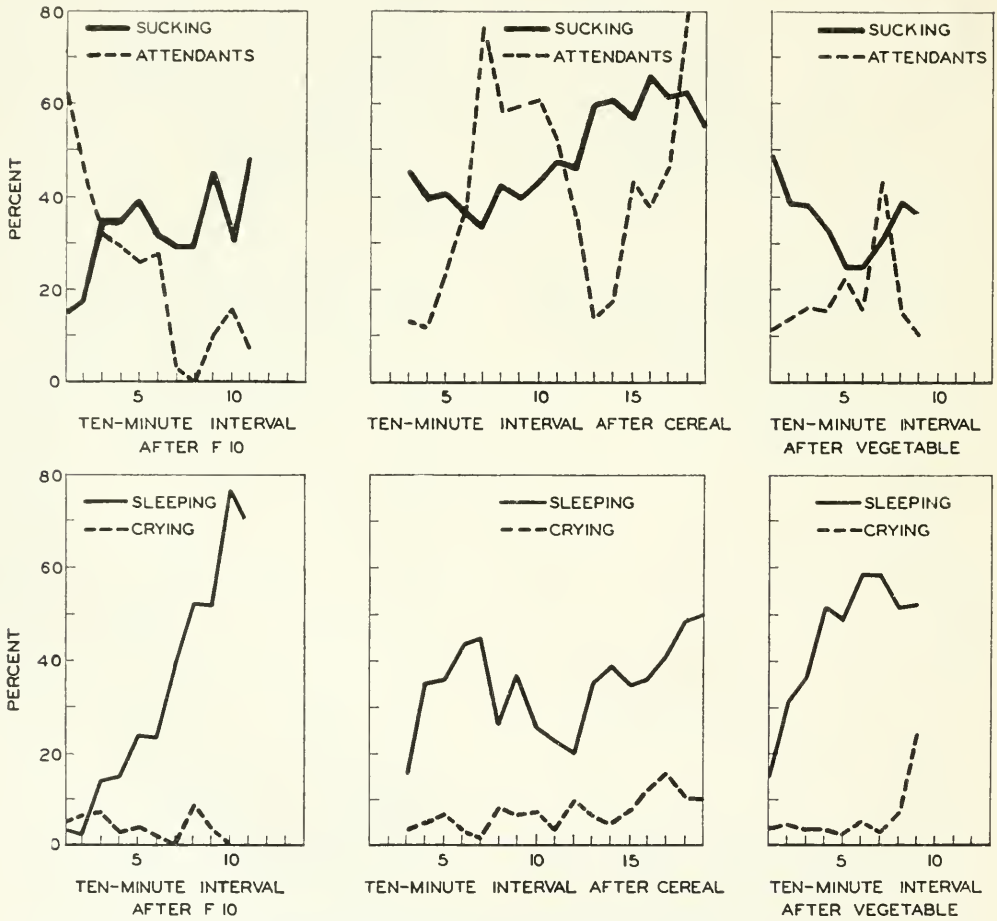

Fig. 5. Frequency of occurrence of sucking, sleeping, crying and presence of attendants in relation to interval after feeding. Age group 17-20 weeks.

TABLE 8

PERCENTAGE OF ALL OBSERVATIONS OF SLEEPING INFANTS IN WHICH SUCKING OCCURRED AND PERCENTAGE OF ALL OBSERVATIONS OF WAKING INFANTS IN WHICH SUCKING OCCURRED

Age of Subjects in Weeks	Per Cent of Sucking While Asleep	Per Cent of Sucking While Awake	Critical Ratio[a]	Age of Subjects in Weeks	Per Cent of Sucking While Asleep	Per Cent of Sucking While Awake	Critical Ratio
1	0.0	12.9	−2.15	27	45.3	36.0	+1.91
2	4.4	12.1	−1.71	28	47.6	28.1	+4.06
3	3.1	16.3	−5.08	29	40.9	29.5	+2.53
4	3.8	26.5	−8.41	30	43.2	27.4	+3.36
5	7.3	32.7	−9.77	31	40.8	25.8	+3.41
6	12.6	28.5	−6.63	32	40.9	36.6	+ .91
7	12.6	29.9	−7.52	33	37.8	27.9	+2.06
8	17.6	40.1	−9.00	34	43.8	31.8	+2.00
9	22.1	36.7	−5.21	35	44.5	25.1	+3.96
10	28.2	41.6	−4.47	36	35.1	19.2	+3.12
11	36.5	41.4	−1.53	37	40.0	22.5	+3.24
12	35.1	45.7	−2.47	38	41.1	16.7	+4.28
13	45.9	48.1	−2.87	39	60.2	22.5	+6.39
14	33.3	45.8	−3.21	40	49.0	20.2	+5.14
15	35.0	42.3	−1.83	41	39.0	25.3	+2.69
16	34.6	41.6	−1.63	42	50.4	31.6	+3.48
17	43.8	44.0	− .04	43	53.4	25.5	+3.82
18	48.4	37.8	+2.59	44	45.9	28.8	+2.71
19	32.0	35.9	− .98	45	42.9	25.2	+3.34
20	39.8	35.5	+1.10	46	44.4	27.3	+2.95
21	49.8	41.6	+2.05	47	41.8	30.7	+1.79
22	43.8	38.7	+1.11	48	42.9	21.7	+3.31
23	37.0	35.8	+ .30	49	30.6	35.7	− .59
24	50.3	36.9	+2.79	50	64.3	33.3	+3.88
25	41.4	36.2	+1.18	51	48.9	31.7	+2.10
26	38.6	31.3	+1.62	52	63.2	22.4	+3.40

[a] (+ indicates a higher percentage of sucking during sleep, − during waking.)

ten weeks and again from the thirtieth to the fifty-second weeks. The least significant differences occur at the ages when the sharp descent in the proportion of time devoted to sleep during the part of the day observed has just given way to a slow and gradual decrease. This trend is seen readily in Figure 15. It should be pointed out that from the first to the fourth week of life, each sample of behavior during sleep includes slightly more observations than the corresponding sample of behavior during wakefulness. From the fifth week on, the samples for the waking period are always more numerous than those for sleep at the comparable ages.

The consistency of the trends revealed by Figure 14 leaves no doubt but that the young infant tends to suck relatively less during sleep, while the reverse is true for the infants of five months or older.

The fact that the young infants who sleep during a greater proportion of the day do proportionally more sucking while awake, and that older infants who sleep less and less during the day, as shown in Figure 15, do an increasing proportion of sucking during sleep, suggests the possibility of sucking being an acquired adaptation to a need or discomfort, possibly becoming more habitual and automatic with increase in age. This conclusion must be considered in connection with our interpretation of sucking trends to be discussed on pages

53 to 57. As we will indicate there, the infant's developing strength and manipulatory power are at first an aid in acquiring the habit of thumb and finger sucking, for this behavior is one of the few activities of interest to him during his waking hours. But as the infant's powers of manipulation and observation increase, they are a means of widening the number of activities open to the child and compete with thumb-sucking for attention during the infant's waking hours.

At all ages increasing numbers of infants fall asleep as time elapses after the meal. The curves, depicted in Figures 1 to 10, of the percentages of infants asleep at each interval following the ten o'clock formula, for example, reveal practically a linear relationship between the number of children sleeping and distance of

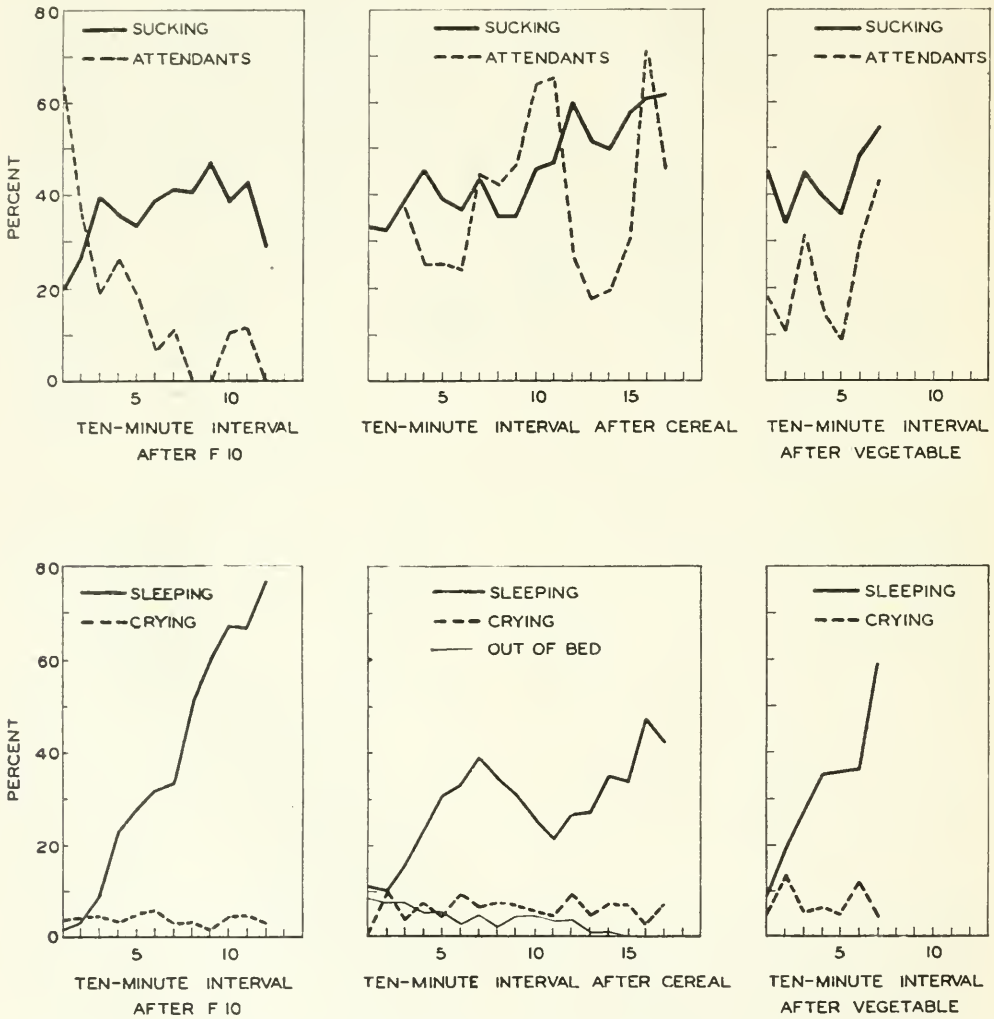

FIG. 6. Frequency of occurrence of sucking, sleeping, crying, location and presence of attendants in relation to interval after feeding. Age group 21-24 weeks.

observed period in time from the meal up to the tenth interval, after which time sleep tends to decrease in frequency. It is interesting to note, however, that in the first three age groups the number of observations during which infants were asleep immediately after and during the first hour after the meal is considerably higher than in subsequent age groups. It follows then that relatively more sleep-

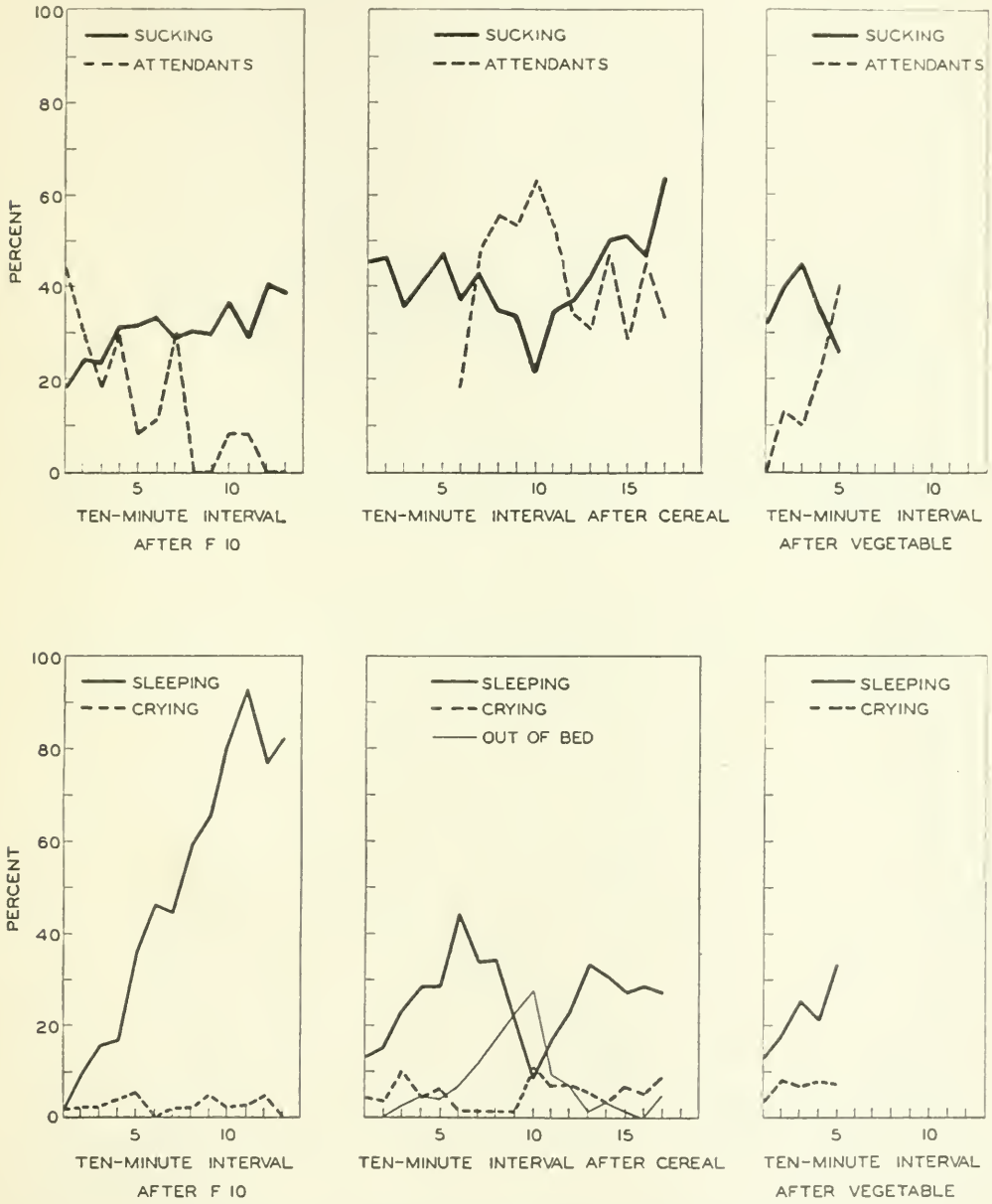

FIG. 7. Frequency of occurrence of sucking, sleeping, crying, location and presence of attendants in relation to interval after feeding. Age group 25 28 weeks.

ing was done by the youngest infants during the period of least hunger, whereas within certain limits the reverse obtained for the older infants. Furthermore, the older infants had shorter fasting periods during the part of the day under observation because they were fed more meals. About two hours after the

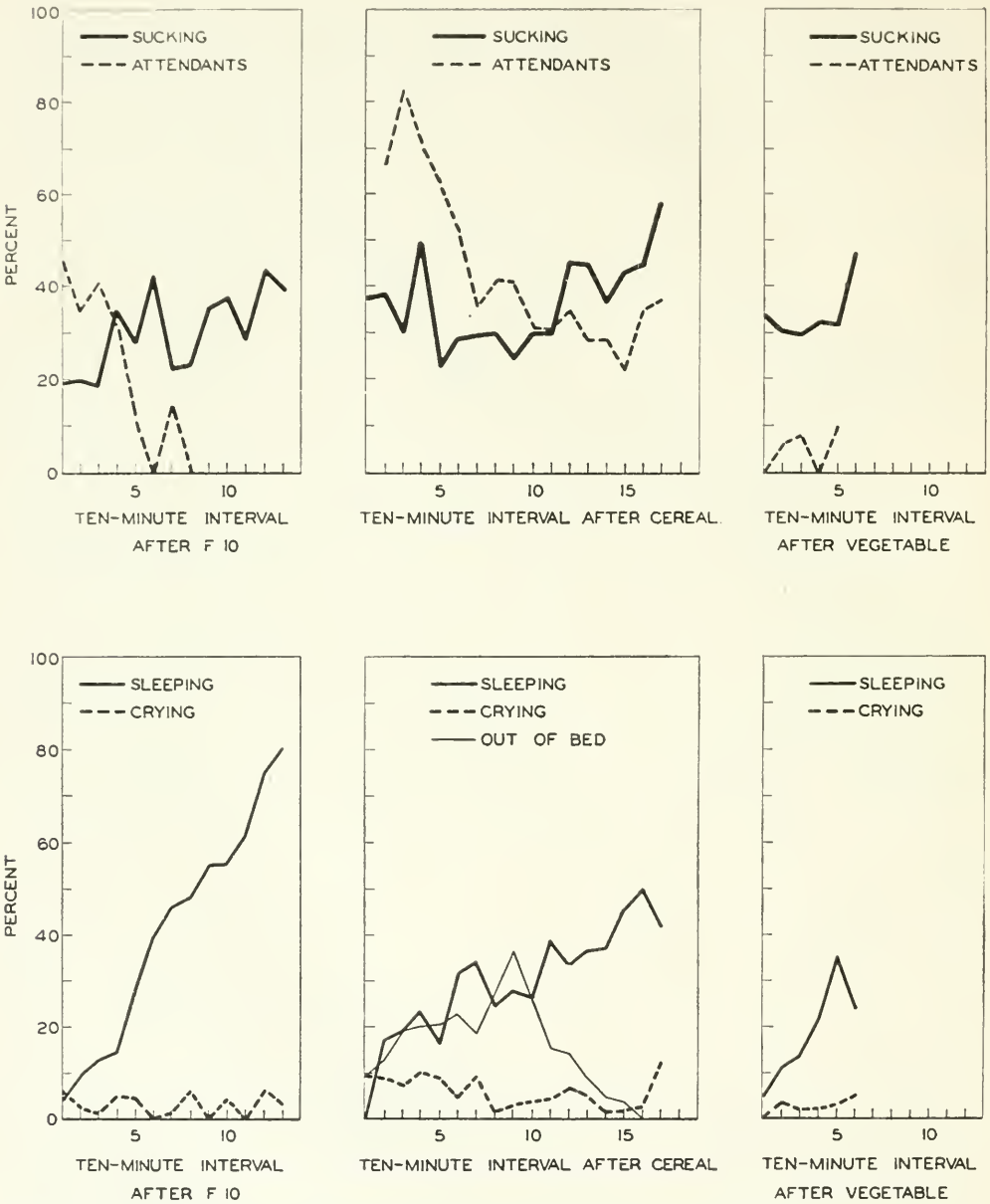

FIG. 8. Frequency of occurrence of sucking, sleeping, crying, location and presence of attendants in relation to interval after feeding. Age group 29-32 weeks.

ten o'clock formula, for example, the infants of seventeen weeks and older were awakened, if necessary, to insure their partaking of the vegetable meal. We had little opportunity, then, after the ten o'clock formula at least, to observe these infants after they had been without food for a relatively long time. In contrast

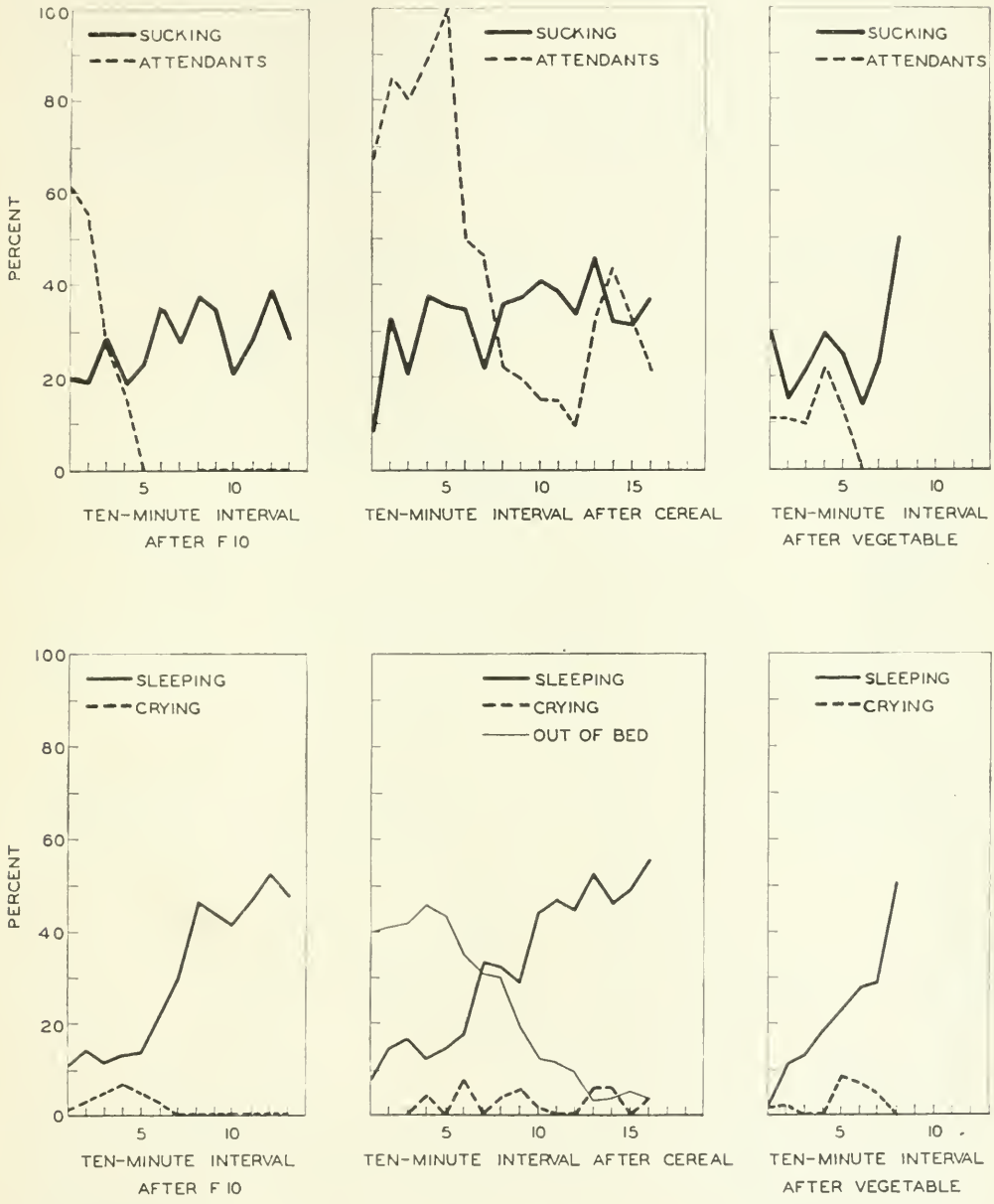

FIG. 9. Frequency of occurrence of sucking, sleeping, crying, location and presence of attendants in relation to interval after feeding. Age group 33-36 weeks.

with these older infants, the youngest not only had a tendency to go to sleep a little earlier after the ten o'clock formula meal, but also to sleep longer. The majority of infants awakened at about two and one-half to three hours after the meal, probably because they were hungry. Hence they were observed as a rule when both hungry and awake. If hunger is a factor facilitating sucking on the part of infants, it is clear, then, that we would expect more sucking in these young babies as a group during their waking hours.

The majority of the older infants tended not to fall asleep until about the second hour after eating. Such sleep habits mean that the infants were more apt to be asleep when hunger contractions began. Moreover, any tendency to suck or to fall asleep during the early intervals after the cereal meal was interfered with by the stimulation of being

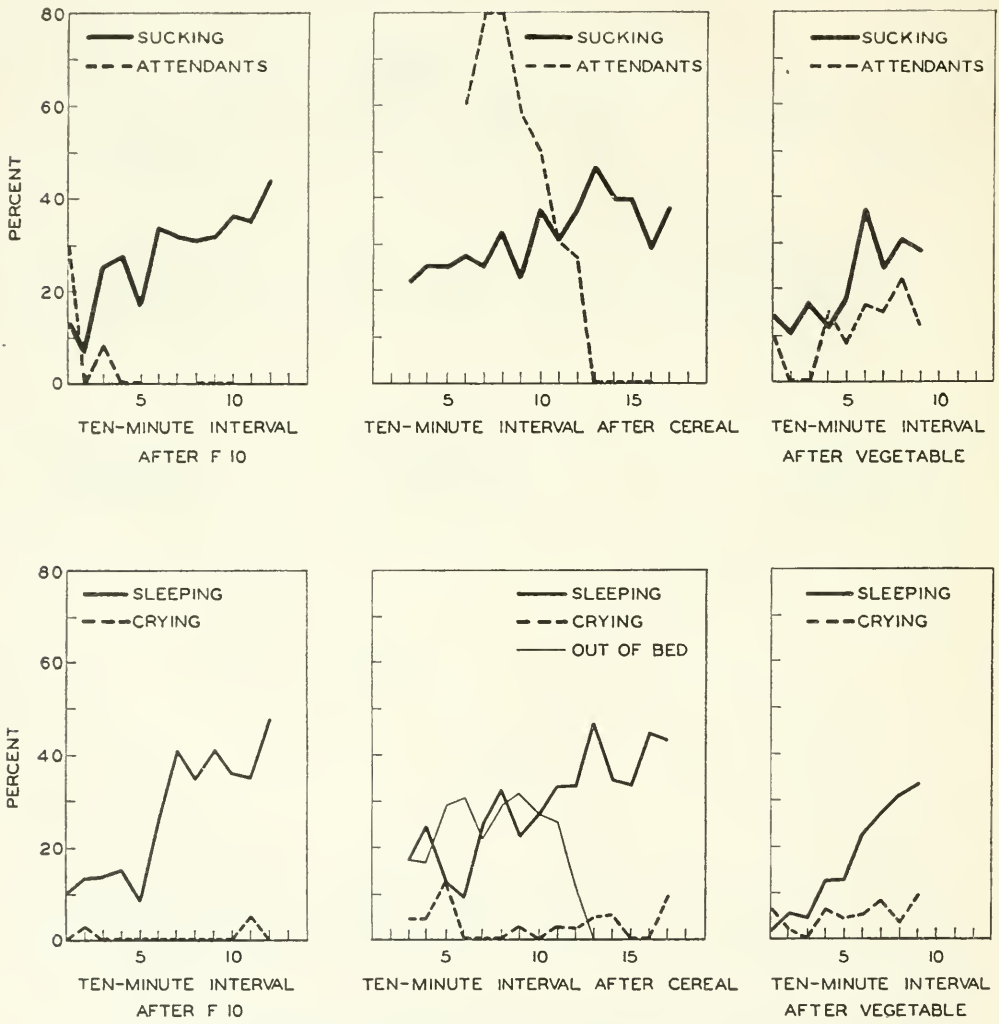

FIG. 10. Frequency of occurrence of sucking, sleeping, crying, location and presence of attendants in relation to interval after feeding. Age group 37-40 weeks.

out of bed. It is thus not surprising to find more sucking done by the older babies during the later fasting intervals when hunger was apt to be present, and when sleep was more frequent.

We conclude that there is no basic or very dynamic relationship between sucking and sleep, but rather a dependence of sucking upon the presence of hunger, with the relations between sleep and

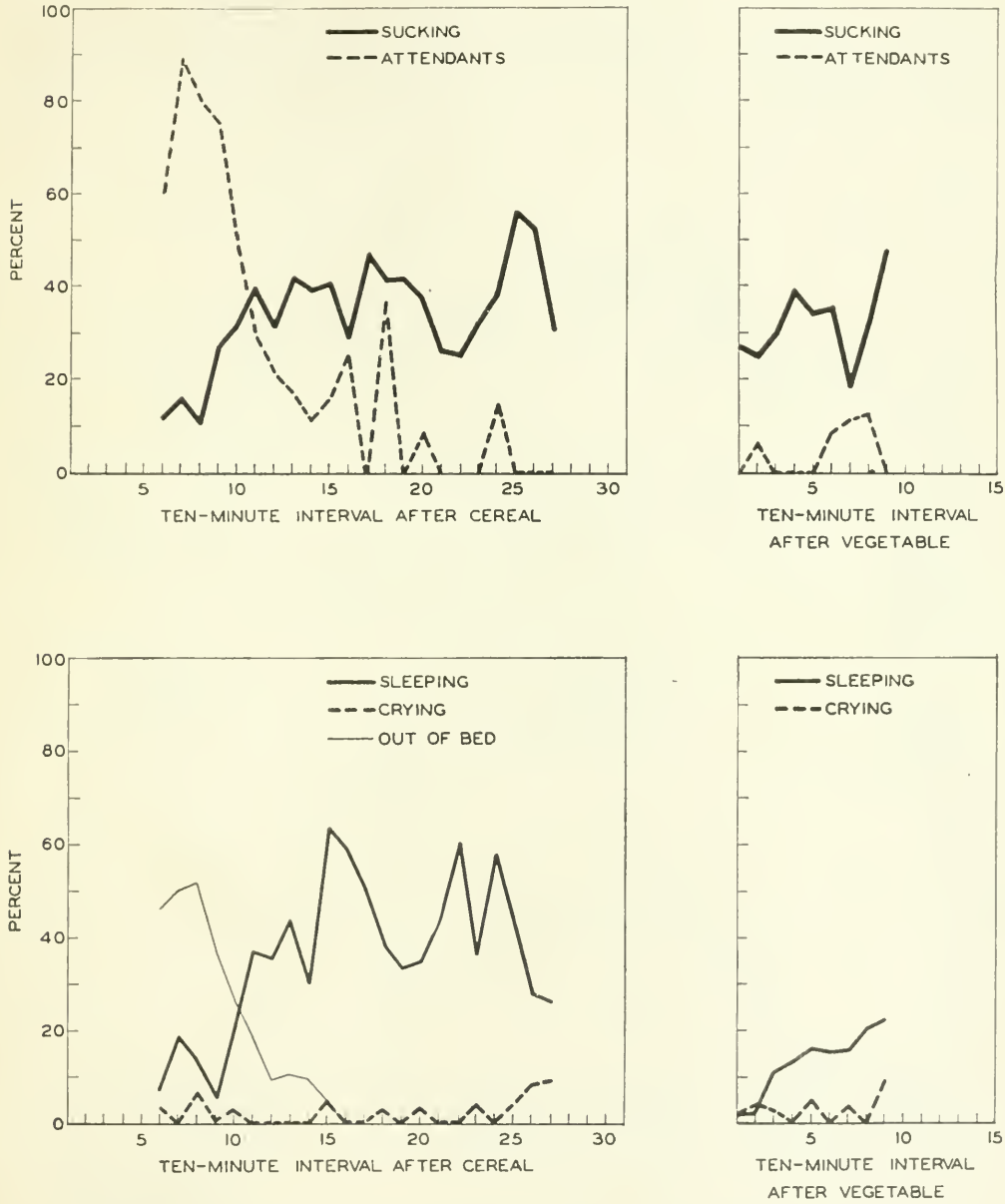

FIG. 11. Frequency of occurrence of sucking, sleeping, crying, location and presence of attendants in relation to interval after feeding. Age group 41-44 weeks.

sucking that we have observed being a by-product of the more basic interdependence of the latter two variables and certain contingencies of the babies' schedules.

This conclusion is given additional support by an examination of the relationship between frequency of sucking and length of fasting interval found for sleeping babies only and for awake babies

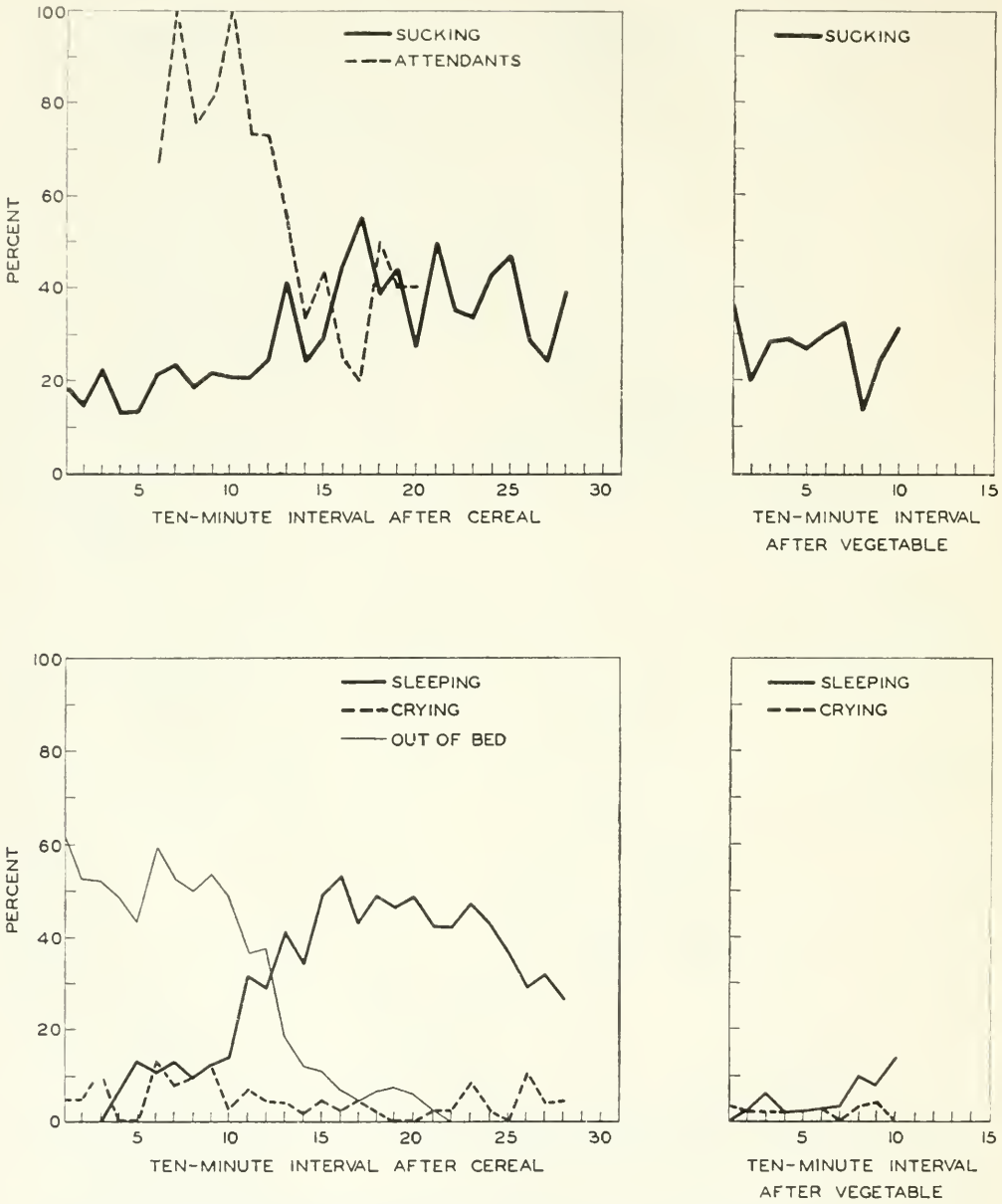

FIG. 12. Frequency of occurrence of sucking, sleeping, crying, location and presence of attendants in relation to interval after feeding. Age group 45-48 weeks.

only. These variables were plotted for the period of time following the two morning formulas and the cereal meal. Some of these curves are presented in Figures 16 and 17. Limitations of space prevent the inclusion of all the charts. The fact that the upward trend in sucking as time elapses after the meal is found for both sleeping and awake infants indicates clearly that this increase in sucking does not depend upon the incidence of sleep.

b. *Crying.*—It was felt that data concerned with the presence or absence of crying during our observations would be revealing, since this response decreases markedly with age and varies directly with hunger. Figure 15 shows for children of various ages the proportion of observations made during which crying

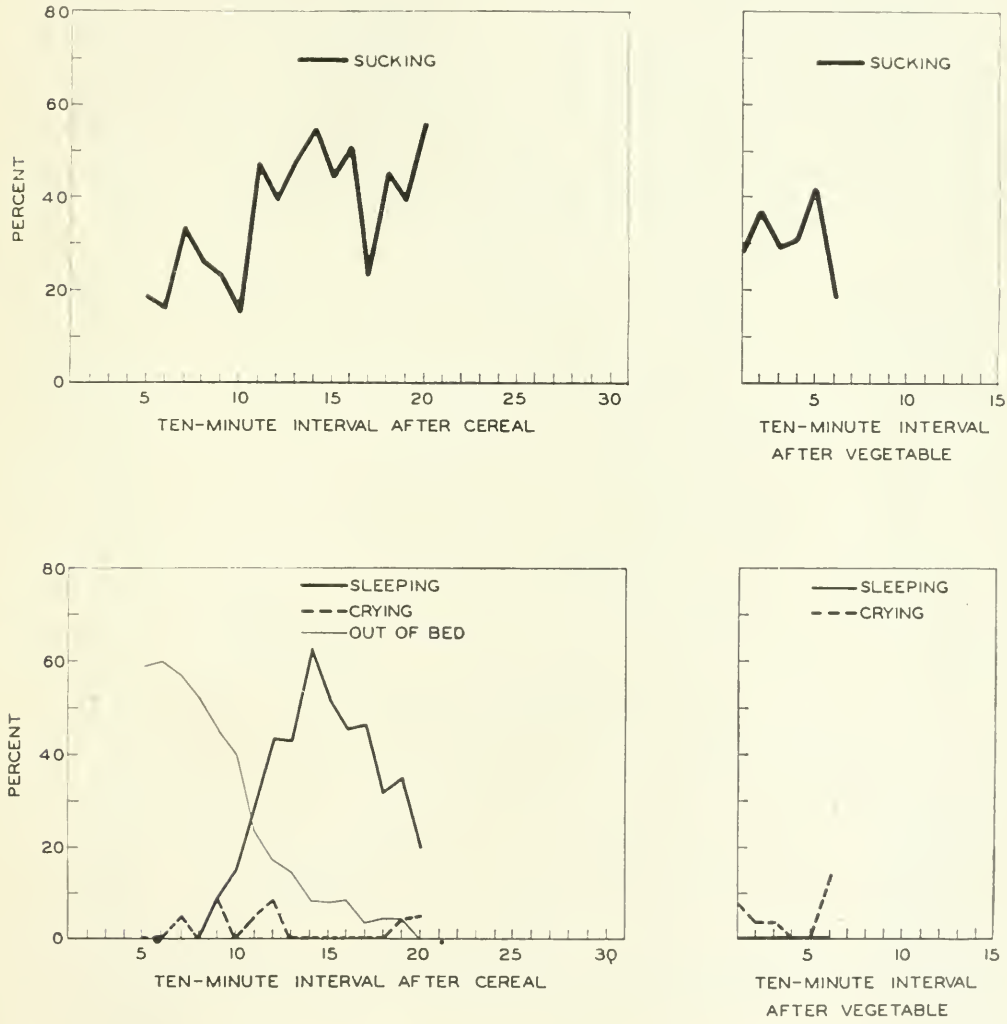

Fig. 13. Frequency of occurrence of sucking, sleeping, crying and location in relation to interval after feeding. Age group 49-52 weeks.

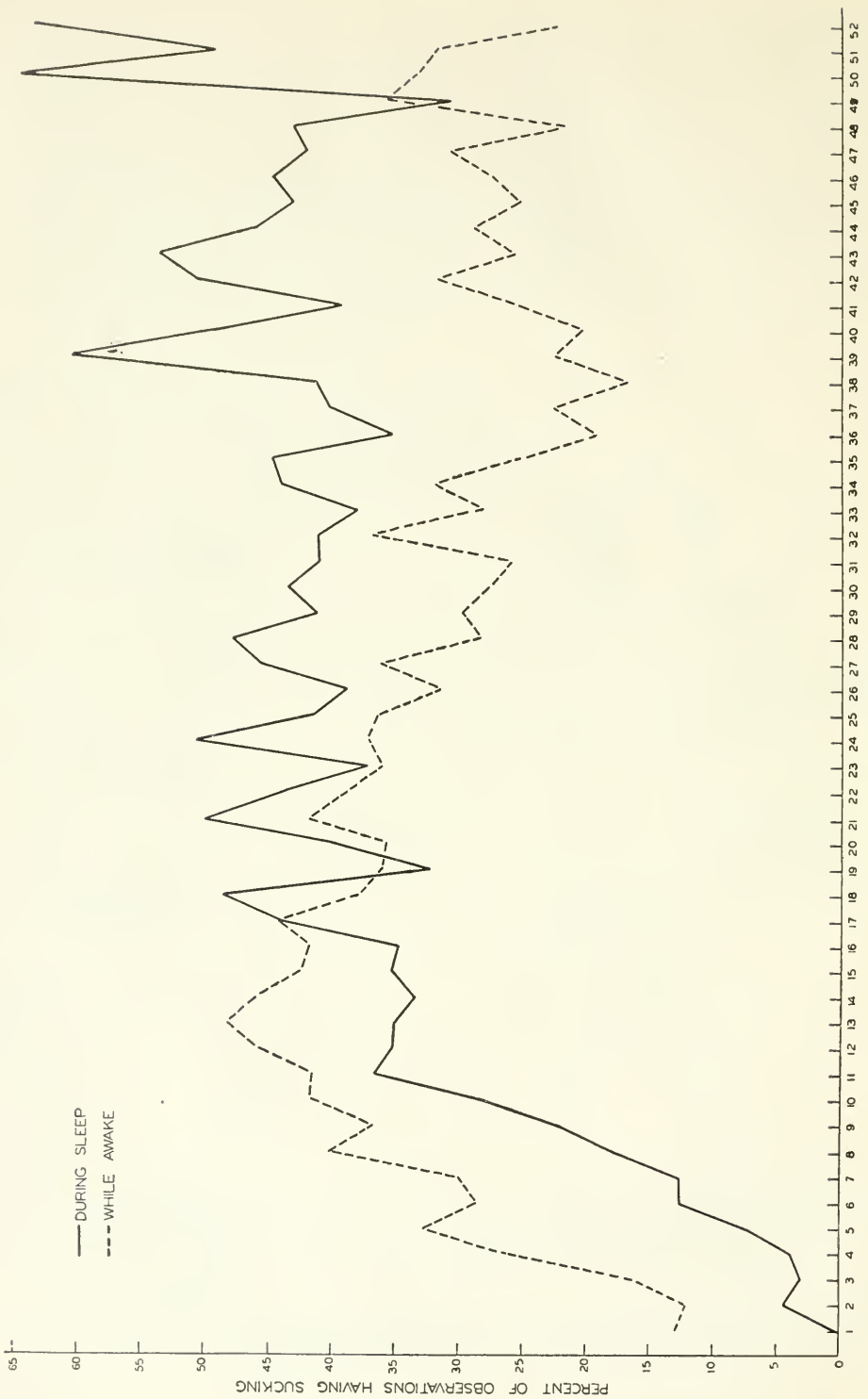

FIG. 14. Sucking during sleep—and while awake.

occurred. The number of observations at each week of age upon which the data of Figure 15 are based is identical with the number listed in Table 15. It was not considered necessary to tabulate the instances of sucking while the infant was crying because the occurrence of such association was very infrequent. It is quite possible that as an infant grows very hungry he tends to cry, a response which can occur simultaneously with sucking only with great difficulty. Hence, while hunger is greatest, sucking may be least because a more violent adaptation, crying, has come to the fore. The tendency toward increased crying during later intervals after the meal was particularly noticeable in infants of the first three months of life.

c. *Number of attendants present.*— Since it was considered likely that the social stimulation the infants received from attendants in the room would interfere somewhat with sucking, an analysis was made of the relationship between the frequency of sucking and the number of attendants present in the room. Figure 18 presents the findings. In this figure "B" refers to the bath situation. While the child was being bathed or waiting for his bath from four to six nurses might have been present in the room. All observations comprising the "B" curve were made on infants awaiting their bath, but never during the bath. It should be pointed out also that

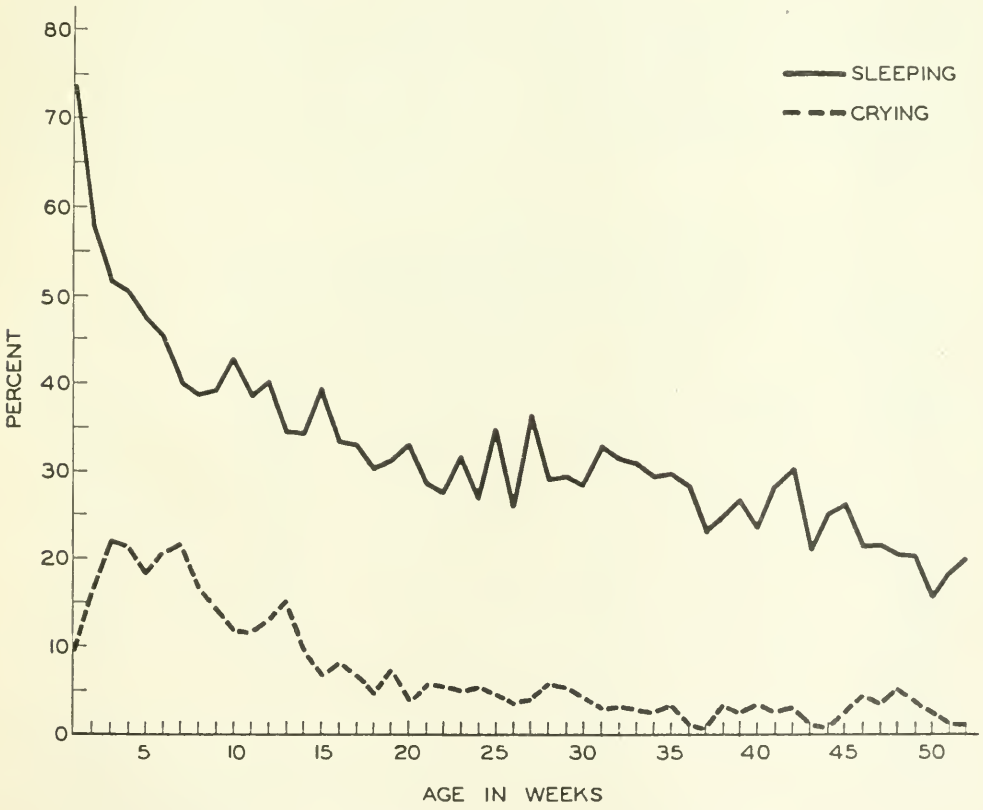

FIG. 15. Percentage of observations in which infants were sleeping and crying.

beginning at about twenty weeks, the children were likely to be on the floor or set up in chairs while they were waiting for their bath. Hence in the B curve the sharp drop in sucking from its peak at thirteen to sixteen weeks cannot be interpreted as due only to the increased number of attendants present. The other curves in Figure 18 suggest that more sucking occurred when the children were alone than when attendants were present, especially after the children were three months old.

Table 9 presents sucking scores and critical ratios between these scores obtained under conditions varying at least as to number of attendants present. No very significant differences between the relative frequencies of sucking under these specific conditions of stimulation occurred until ages seventeen to twenty weeks, from which time on the differences were fairly consistently in favor of more sucking while an adult was not in the room.

What is surprising is that sucking seemed to occur in some age groups as frequently when there were two attendants in the room as when no adults were present. It is possible that this finding can be explained by the fact that the presence of two attendants usually meant feeding time. The clinking of bottles and other acts by the nurses may stimulate anticipatory feeding reactions of which sucking may be one.

The differences in frequency of sucking seen under the conditions when no attendant was present and conditions obtaining at the time of bathing are consistently significant among the babies of six months and older.

It is of interest to note the striking similarity in frequency of sucking among infants up to the thirteen to sixteen weeks group, regardless of the number of attendants present. This age group is the one at which the relative frequency of sucking for the waking period is highest, and supplies evidence to substantiate the

TABLE 9

AMOUNT OF SUCKING AND CRITICAL RATIOS BETWEEN PERCENTAGES OF SUCKING FOR CONDITIONS IN WHICH VARIOUS NUMBERS OF ATTENDANTS WERE PRESENT

Age of Subjects in Weeks	Per Cent of Sucking for Periods: When 0 Attendants Were Present	When 1 Attendant Was Present	When 2 Attendants Were Present	When Child Awaited Bath	When 0 and when 1 Attendant Were Present[a]
1– 4	8.3	8.0	6.3	17.5	+ .12
5– 8	27.3	25.4	31.0	22.8	+ .61
9–12	34.2	35.2	36.9	33.9	− .32
13–16	40.5	31.0	35.0	38.5	+2.71
17–20	41.7	30.9	21.6	29.8	+3.27
21–24	42.1	31.5	36.7	23.2	+2.72
25–28	31.1	31.8	40.0	13.3	− .14
29–32	32.4	23.9	15.8	9.5	+1.89
33–36	31.3	31.5	21.1	10.5	− .03
37–40	28.4	17.9	....	2.6	+1.57
41–44	34.9	22.2	....	8.7	+1.51
45–48	26.8	30.0	....	9.9	− .31
49–52	34.3	....	....	14.0	.....

(Continued on page 35)

hypothesis, to be discussed later, that there is a relationship between sucking and developmental level. As the infant becomes more sensitive to his environment he is distracted from sucking to some extent by many stimuli among which are the adults who minister to him.

The higher frequency of sucking during the bath-preparation period by infants of the first month of life can be explained partly by the fact that the infants were likely to be awake at this period—a condition relatively favorable to sucking on the part of the very young. Perhaps even more important is the fact that the bath period occurred from three to four hours after the 6:00 A.M. formula meal, a time when we would expect young infants to be hungry.

Figures 1 to 13 on pages 18 to 31 show numbers of attendants present in relation to interval after feeding. It will be noted that these distributions have somewhat different characteristics after different meals, yet in general it seems that the percentage of observations in which attendants were present decreases as time elapses after the meal. Is the gradual increase in frequency of sucking as time elapses after the meal due, then, to absence of attendants? Such absence has implications in more ways than one for the activities of the infants. Toys, for example, may be thrown out of bed and cannot of course be retrieved until an attendant reappears. Hence the infant may be thrown back upon manipulation of himself for amusement. However, we do not believe we can conclude that the increase in sucking with fasting interval depends upon the decrease in number of nurses in attendance upon the infants because (1) the curves suggest a fairly low negative correlation between amount of sucking and presence of attendants, and (2) an analysis of the data to be presented later, in which the number of attendants present is held constant, re-

TABLE 9—(*continued*)

Critical Ratios between the Sucking Scores for Periods:				
When 0 and When 2 Attendants Were Present[a]	When 1 and When 2 Attendants Were Present[b]	When Child Awaited Bath and When 0 Attendants Were Present[a]	When Child Awaited Bath and When 1 Attendant Was Present[b]	When Child Awaited Bath and When 2 Attendants Were Present[c]
+ .29	+ .25	−1.48	−1.48	−1.23
− .50	− .75	+1.29	+ .68	+1.06
− .43	− .26	+ .10	+ .29	+ .42
+ .98	− .66	+ .34	−1.19	− .46
+3.35	+1.43	+2.43	+ .20	−1.09
+ .76	− .68	+4.02	+ .31	+1.67
−1.11	− .92	+4.56	+3.30	+3.18
+2.68	+1.13	+6.54	+2.88	+ .95
+1.05	+ .95	+4.33	+3.04	+1.03
.....	.....	+6.79	+2.25	.....
.....	.....	+7.24	+1.50	.....
.....	.....	+3.13	+1.97	.....
.....	.....	+2.11	.....	.....

[a] (+ indicates more sucking when 0 attendants were present.)
[b] (+ indicates more sucking when 1 attendant was present.)
[c] (+ indicates more sucking when 2 attendants were present.)

veals the same trend as do results in which the attendants variable is not controlled; namely, for sucking frequency to increase the longer the infant is without food.

d. *Location of the infant.*—The location of the infant is a variable that did change during the period following the cereal meal. Hence, if the quarters in which a child is confined have some influence on the amount of sucking he does, we must get some estimate of the degree of this influence before we can draw conclusions relative to the effect of fasting interval upon sucking.

Between the ages of twenty to twenty-eight weeks of age, the infants in this study began to sit up in chairs or walkers, or to play on the floor, for an interval of at least a half hour after the cereal meal. It can be seen in Figures 6 to 13 just how frequently these activities occurred during each ten-minute interval following the cereal meal. We have

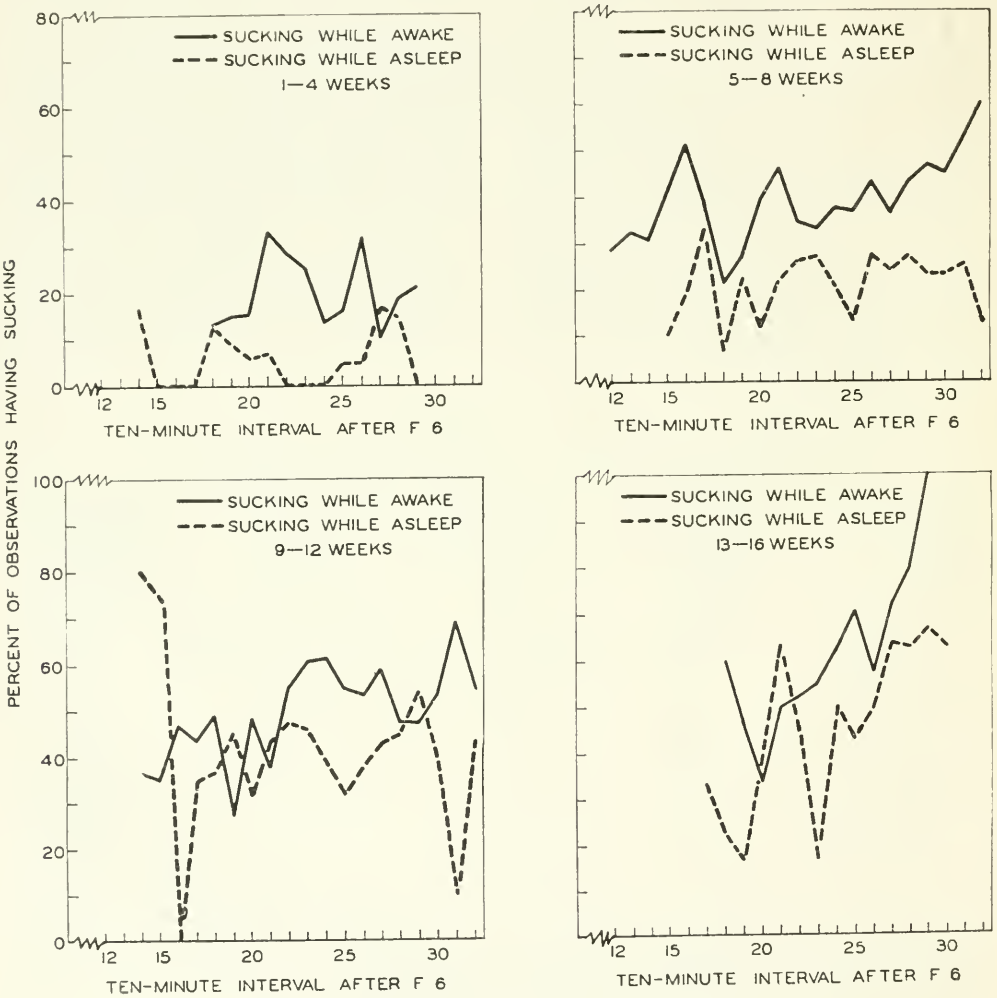

Fig. 16. Sucking during sleep—and while awake.

grouped together all observations made on infants who were on the floor and on infants who were sitting up in chairs and have designated these observations on the chart, "Out of Bed." Figure 19 gives the sucking score obtained under these conditions and the average sucking score based on all observations. Since the latter average is based on data which include the observations made when the children were out of bed the contrast is not so sharp as we might wish. However, the data comprising "all observations" are heavily weighted with instances of infants being in bed, since the infants spent most of their time in bed. Each point plotted in the curves of sucking by infants who were on the floor or in

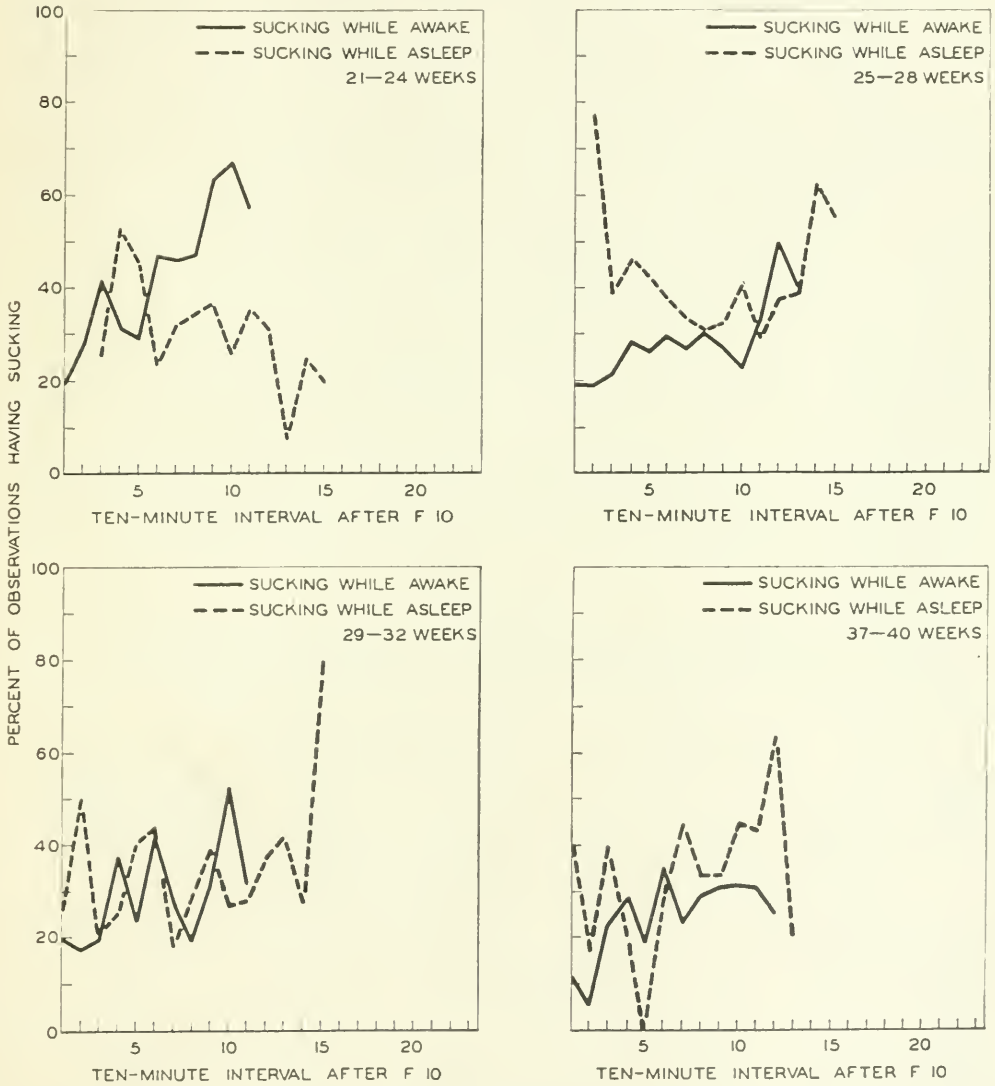

Fig. 17. Sucking during sleep—and while awake.

chairs is based on from twenty to 124 observations. The blanks in the figure represent conditions under which less than twenty observations were taken. Table 10 presents the sucking percentage scores and the critical ratios between the group scores describing group behavior when the children were in various situations. Even though we cannot escape the fact that many influences other than confinement to bed may have been at work to raise the general level of sucking in the total data curve, nevertheless it seems safe to conclude that there was less sucking when the infant was placed in a more stimulating location than when he was in bed. The influence on our findings of the variable of individual differences we believe is fairly well controlled because the sucking frequencies in the total data curve are based on the behavior of the same children who determine the curve of sucking for infants out of bed. Then, too, the consistency of the differences in sucking frequency in the two sets of data, over such a wide range of ages, in children in different wards, in the care of different attendants, and even on different feeding schedules, makes it seem unlikely that the effect of the occupation factor is not strongly mirrored in our findings.

The question arises, of course, concerning the role of hunger in the determination of the pattern of the findings just described. Inspection of Figures 6 to 13 shows that, in the case of some age groups at least, infants tended to be out of bed more frequently during the intervals closely following the meal than later. Hence we might well argue that the low frequency of sucking by the infants at these times was due to satiation of hunger as well as to the influence of a stimulating environment. Conversely, we might ask whether the increase in sucking at later intervals after the meal was due primarily to the removal immediately after feeding of factors that tended to inhibit sucking. That is, was the low frequency of sucking during the early intervals after the meal dependent upon such factors as the presence of nurses in the room or the infants being out of

TABLE 10

PERCENTAGE OF OBSERVATIONS IN WHICH SUCKING OCCURRED AND CRITICAL RATIOS BETWEEN THE GROUP MEANS OF THESE PERCENTAGES BASED ON THE TOTAL DATA AND ON THOSE DATA FOR THE CONDITIONS IN WHICH THE INFANTS WERE OUT OF BED

Age of Subjects in Weeks	Per Cent of Sucking for Infants:			Critical Ratios[a] between Sucking Averages for All Conditions and:		Critical Ratio between Sucking Averages for Infants Placed on the Floor and for Infants Set Up in Chairs
	Under All Conditions	When Placed on the Floor	When Set Up in Chairs	Condition When Infants Were Placed on the Floor	Condition When Infants Were Set Up in Chairs	
21–24	40.3	....	21.2	.....	+2.65	....
25–28	35.9	3.5	8.8	+9.56	+6.78	1.08
29–32	33.3	16.7	10.3	+2.16	+7.67	.79
33–36	30.0	15.4	10.6	+2.52	+5.54	.73
37–40	27.0	....	6.0	.....	+6.77	....
41–44	32.3	8.8	7.3	+6.35	+6.76	.30
45–48	30.1	8.9	17.7	+7.07	+3.35	2.00
49–52	35.4	16.4	17.3	+3.58	+3.85	.13

[a] (+ indicates a higher percentage of sucking under "All Conditions.")

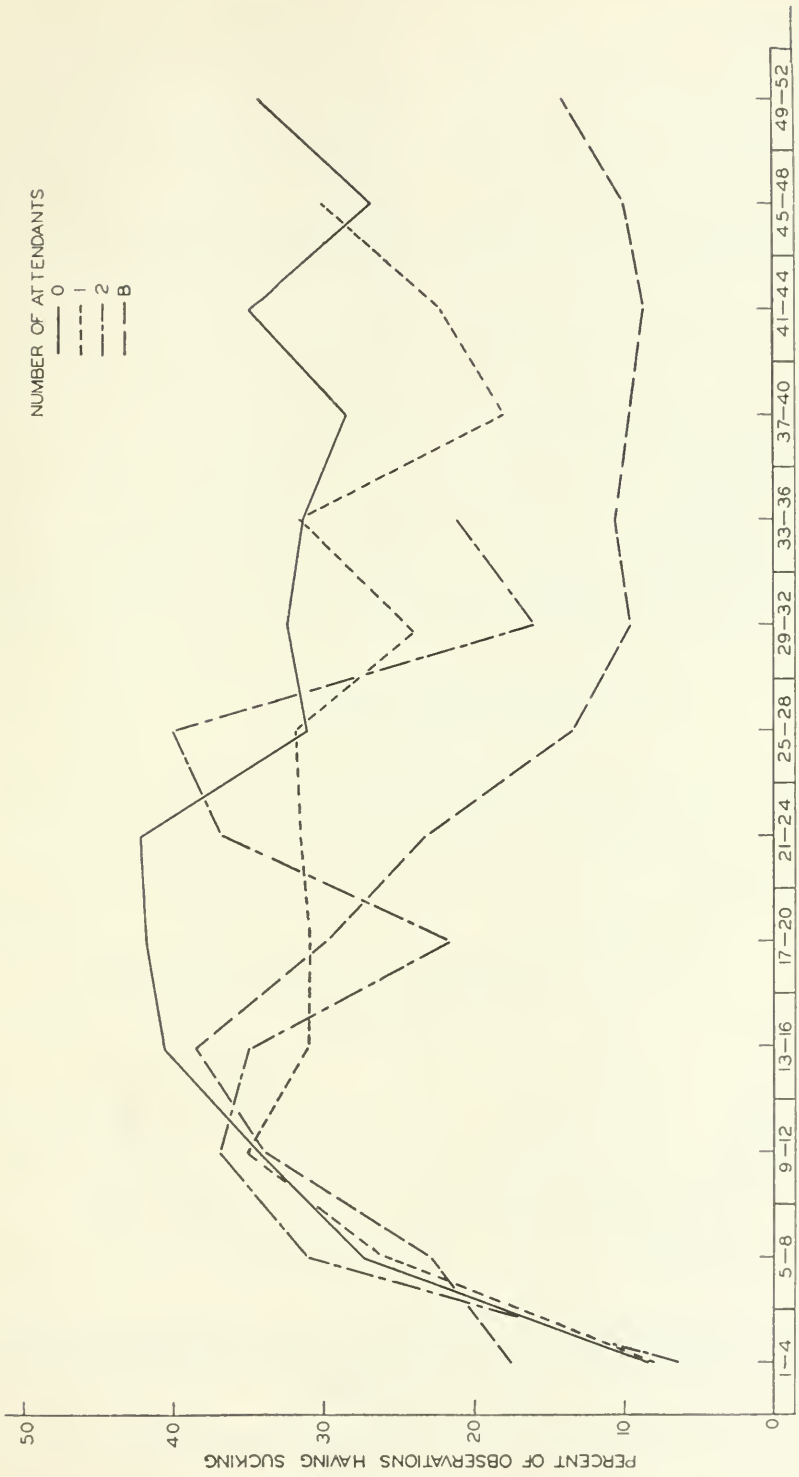

FIG. 18. Sucking in relation to the number of attendants present.

bed? That this was not the case was demonstrated by plotting the sucking behavior of groups of infants who were in the same general environmental setting. The frequency of sucking observed in successive ten minute intervals after feeding was charted for infants who were awake, in bed, and had no attendants present. Figure 20 presents some of these sucking curves for the period after the cereal meal. Quite a few of the points in these curves are based on considerably less than twenty observations. This causes the fluctuation of the sucking scores from interval to interval to be greater than was true in the case of the total-data curves already presented in Figures 1-13. However, the positive relation between sucking frequency and time interval elapsing since feeding is still shown strikingly.

c. *Body position.*—It occurred to us that whether or not a baby managed to get his hand into his mouth might depend upon his position. If such a relationship were found to obtain, we would want to have some idea of the frequency of occurrence of different body positions at the various intervals following a meal, before we formulated conclusions concerning the influence of fasting interval upon sucking. In order that we might be able to check on these body position variables, we recorded the position of the infant during each of 10,000 behavior samples, about half of which were gathered during our preliminary study. A child's position was described as either prone or supine, or miscellaneous. If the child was prone, it was noted whether

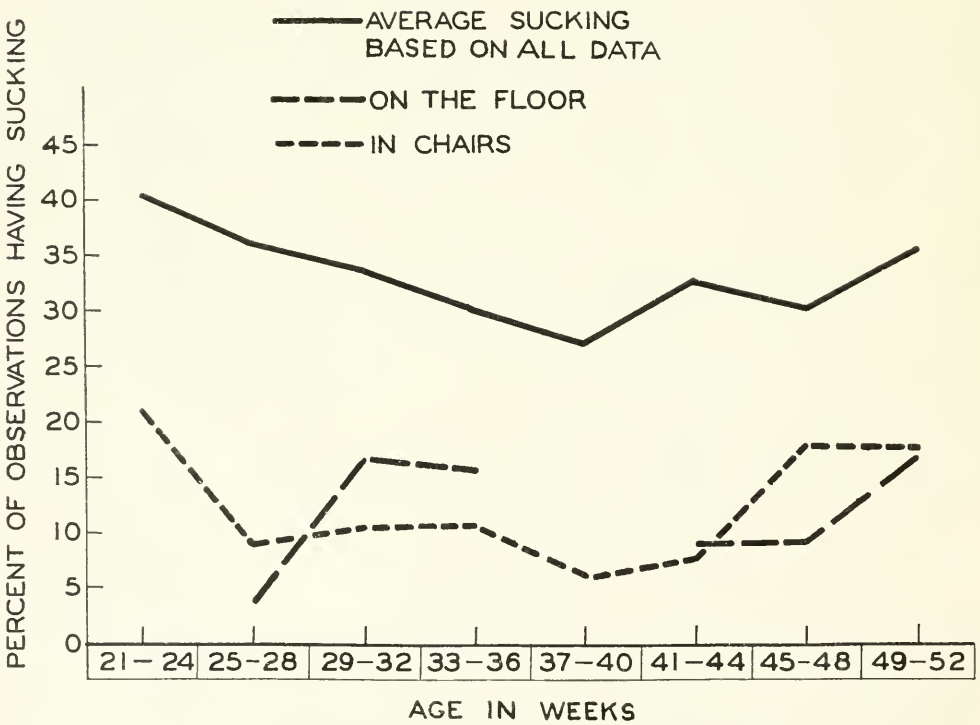

Fig. 19. The relation between sucking and location of child.

the head was centered or turned to the right or left. The category, "supine," was divided into three similar sub-classes. In the category, "miscellaneous," we placed all samples not readily classifiable in the groupings just mentioned.

The frequencies of sucking under four of these postural conditions are described in Figure 21 and in Table 11. The data for the other positions are omitted because the number of instances observed was so few. Each point charted has had its position defined by the data from at least ten observations. Ninety per cent of the points represent twenty or more observations. We did not investigate the factor of individual preference for certain positions for we have no reason to

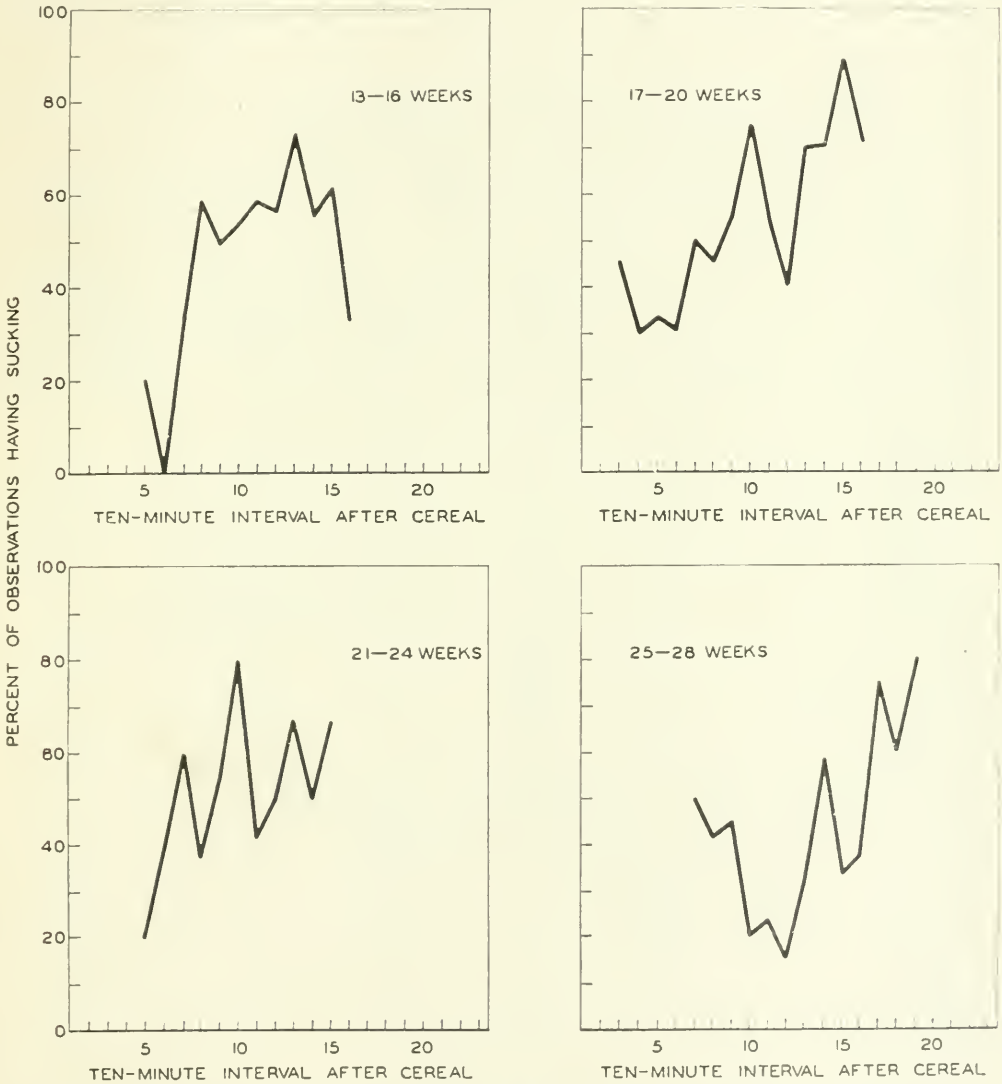

FIG. 20. Sucking curves for infants who are awake, in bed, and have no attendants present.

believe that a young infant is free to indulge position preferences. From birth to about eighteen weeks of age, the period during which our results do suggest a relationship between body position and sucking, infants are incapable of shifting from the prone to the supine position or vice versa. We might mention at this point that our infants were routinely placed in various positions by the nurses.

According to Table 11 the most striking difference in sucking frequency occurs between the straight prone and the straight supine positions. During the early weeks, there is clearly more sucking when the infant is in the prone than in the supine position. This finding seems readily explainable in terms of the characteristic flexed position of the infant's arms at these ages. When the infant is prone his flexed arms are apt to be very

TABLE 11

PERCENTAGE OF SUCKING AND CRITICAL RATIOS BETWEEN MEANS OBTAINED FOR INFANTS OBSERVED IN VARIOUS POSITIONS

Age of Subjects in Weeks	Per Cent of Sucking When Infants Were:				Critical Ratio* between Average Sucking Scores:	
	Prone	Supine	Prone with Head to Side	Supine with Head to Side	For Prone Infants and for Supine Infants	For Prone Infants with Head to Side and for Supine Infants with Head to Side
2	18.2	8.8	36.7	10.6	+ .75	+3.78
3	9.1	3.2	10.7	9.3	+1.07	+ .45
4	20.0	6.4	14.4	8.7	+3.16	+1.63
5	25.0	3.9	28.5	16.5	+2.57	+2.55
6	36.8	8.3	33.8	21.3	+2.46	+2.78
7	11.5	4.7	46.6	27.3	+ .94	+3.94
8	27.3	10.0	33.8	40.1	+1.97	−1.26
9	7.1	7.9	34.7	41.7	− .20	−1.25
10	13.6	4.5	39.0	38.6	+1.15	+ .07
11	23.1	11.0	59.3	48.6	+ .98	+1.39
12	23.5	8.3	40.2	54.2	+1.41	−1.79
13	35.7	9.4	46.5	40.4	+1.91	+ .69
14	42.1	14.1	44.1	46.6	+2.32	− .26
15	53.8	9.8	46.2	50.9	+3.03	− .67
16	68.8	6.1	32.2	37.3	+4.12	− .80
17	33.3	21.6	45.1	60.0	+ .59	−1.80
18	47.4	33.8	44.1	56.6	+1.06	−1.60
19	30.8	29.5	44.9	55.2	+ .09	−1.16
20	....	....	35.7	39.9	.....	− .62
21	....	....	84.4	43.9	.....	+6.04
22	....	....	54.7	49.0	.....	+ .45
23	....	....	46.8	31.4	.....	+1.57
24	....	....	53.4	52.0	.....	+ .09
25	....	....	33.3	49.0	.....	−1.11
26	....	....	37.3	14.8	.....	+2.32
27	....	....	10.0	28.6	.....	− .95
28	....	....	37.0	40.0	.....	− .02
29	....	....	42.9	54.5	.....	− .58
30	....	....	51.5	36.4	.....	+1.25
31	....	....	29.5	51.7	.....	−1.91
32	....	....	20.7	61.5	.....	−2.14

* (+ indicates a higher percentage of sucking while the infant was prone; −, while supine.)

close to his head and are not very free to move about. The thumb can, however, reach the mouth with ease. On the other hand, when the infant is in the supine position, he can achieve extension of the arms much more readily and is freer to fling his arms about. There is thus a greater variety of activity open to the supine infant and he is less likely to get his thumb in his mouth by accident. Since the mere effort of maintaining the supine position with the head centered may divert some energy from the activity of sucking, the more relaxed position is probably the one of allowing the head to fall to the side. It should be no surprise

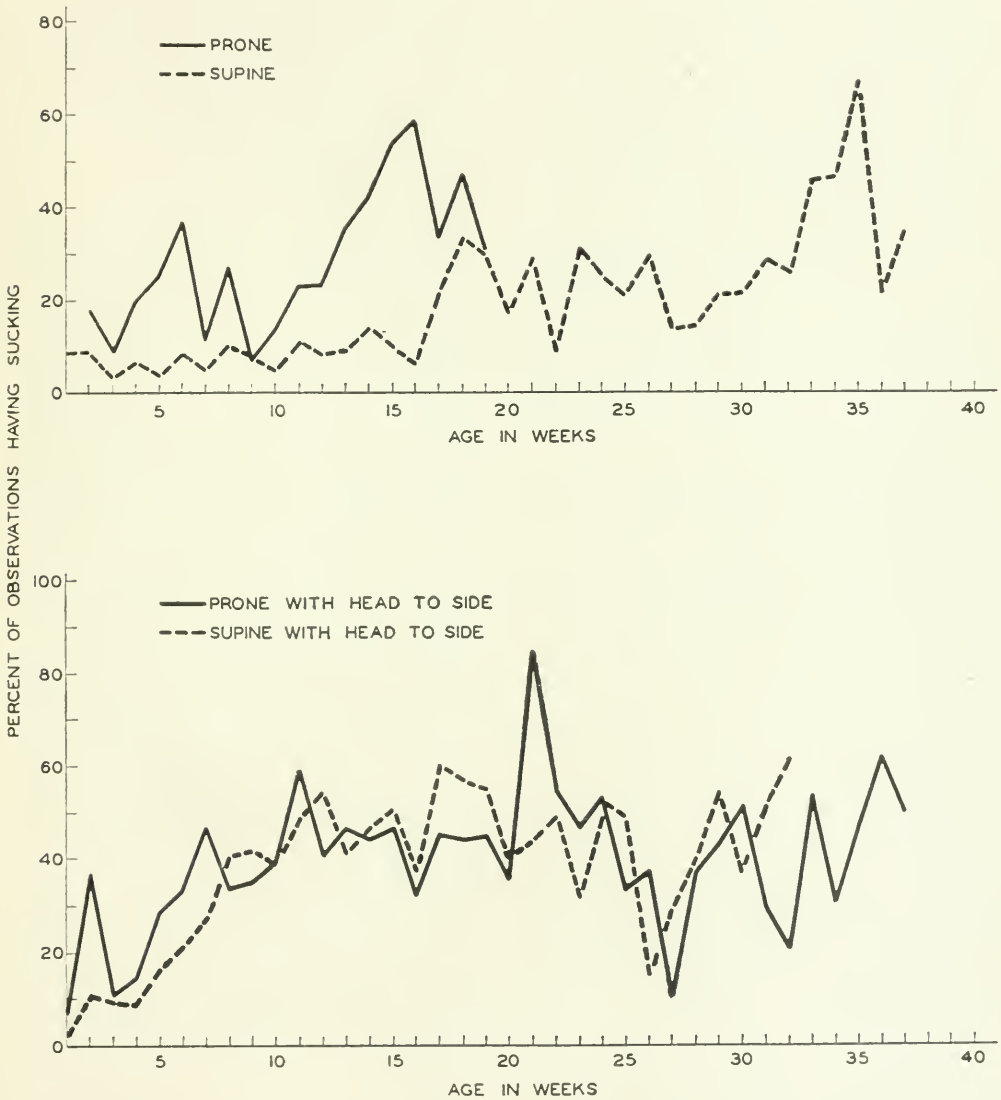

FIG. 21. The relation of thumb-sucking to position of the child.

then that sucking should be observed more frequently when the head is turned to the side.

When comparing the amount of sucking which occurs in the two positions when the head is turned to the side, we note that the prone position is still associated consistently with the greater sucking frequency during the first seven weeks of life, but, according to Table 11, the differences are not statistically impressive. From eight weeks on, however, no consistent difference was apparent between frequency of the sucking behavior observed in infants who were in the prone or the supine positions, with their heads turned to one side or the other. This result might be expected on the basis of greater motor skill of the older infant. When the head is turned to the side it is probable that the mouth can be reached by the thumb with equal ease whether the infant is in the prone or supine position.

It is extremely interesting that DeBuys and Henriques (11) found that the stomach motility of infants in the prone position was greater than when the same infants were placed in the supine position. These investigators studied the stomach motility in only three infants, one of whom was six weeks of age, and the other two, four months old. However, the variables of quality and quantity of food consumed were carefully controlled. The investigators noted in the case of older infants and children that stomach motility was most rapid when the child was lying on his right side. Although we did not record the side on which our subjects were lying when observed, and indeed lying on the side at all occurred so infrequently that we do not present the data on sucking observations in connection with this position, yet what data we have shows a rather consistent tendency toward considerably more sucking while the infant was on his side than when he was either prone or supine.

Tabulation of body position by interval after feeding was omitted because the relationship between these two variables seemed entirely random, except for the first interval or two after the meal, when the youngest babies were routinely placed in the prone position. Removing the influence of body position would point, even more clearly, to a positive relation between sucking and interval after feeding for young babies.

B. SUCKING IN RELATION TO QUANTITATIVE VARIATIONS IN MILK FORMULA

It will be remembered that in the absence of direct measures of hunger, we explored a possible relationship between hunger and sucking by relating sucking to certain variables known to influence hunger. We discussed the influence of fasting interval upon sucking. A second variable known to influence the time of onset of hunger is the quantity of the food eaten. We did not vary this latter factor experimentally but attempted the equivalent of this control by selecting from our total data only the data that threw light on the effect of the food quantity variable. Since the suitable data are very limited the results are at best only suggestive. We therefore merely mention the trend of the results rather than present the data in detail.[1] The unit of comparison in these particular analyses was the amount of sucking done by each of the youngest three lunar-month groups of infants during successive hours following the formula meals which varied in volume.

[1] These data are present in detail in the typewritten copy of the dissertation, on file in The University of Chicago Libaries.

1. *Sucking Behavior of Comparable Age and Weight Groups Receiving Different Quantities in Ounces of the Same Type of Formula*

It so happened that small groups of infants were available who were of the same age and approximately the same weight but were receiving different amounts in volume of the same type of formula a day. The amount of formula given was determined in accordance with generally adopted standards for certain ages. However, variations from child to child came about because of judged differences in individual need. When an infant was regularly consuming his full quota and seemingly demanding more, his formula was increased before that of another infant who seemed to thrive on less frequent increases. It happened also that some infants were given a greater proportion of water or of sugar in a given volume of formula than were other infants. Unfortunately, the caloric value of the formulas was not controlled in this analysis, so that an increase in volume of formula may or may not have entailed an increase in calories.

There were twenty-two instances of more sucking by infants receiving the larger amount of formula, as against eleven instances of more sucking by infants in the small formula group. In two cases, the amount of sucking done by the two formula groups is identical. The greater proportion of the significant differences is found to be in the direction of more sucking by the large formula group.

The finding that the infants fed the most in terms of volume, and in some cases of calories, tended to suck most is not necessarily contrary to our hypothesis that differences in hunger are related in dynamic ways to individual differences in sucking frequency, for it may well be that infants given the larger amount of formula were the infants with the well-nigh insatiable appetites. We are fully aware of the possible effect upon our results of our failure to control the caloric value of the formulas ingested. Whether or not such a control of the caloric value of the formulas would result in different findings is questionable. The infants given an increase in the volume of formula without a corresponding increase in the calories were undoubtedly a selected group. It may have been that such infants were receiving sufficient calories, according to accepted standards, yet because they seemed to demand more food, were given a temporary increase in formula volume only.

2. *Sucking Behavior of Comparable Groups Receiving Different Quantities in Calories of the Same Type of Formula*

By using the method of equated groups we were able to control the factors of caloric value of formula, liquid volume of formula, weight of the child, and, only to some extent, sex of the infant. (See Table 12.) This carefully controlled experiment entailed a sacrifice in number of cases.

Data in Table 13 indicate a decided trend toward more sucking by the low calorie group and thus support our thesis that hunger may influence sucking. The average sucking scores for all between-feeding intervals show more sucking by the low calorie groups in all cases. Of the fourteen possible comparisons of the sucking-score means for intervals of an hour, in ten instances there was more sucking by the group receiving fewer calories. There are two cases of identical sucking scores by both groups, and two instances of more sucking by the high calorie group, the latter two scores being

TABLE 12

DESCRIPTION OF SUBJECTS USED IN THE HIGH AND LOW CALORIE GROUPS

	Evaporated Milk Group		Enzyme Milk Group	
Number of pairs	7		21	
Number of male pairs	1		7	
Number of female pairs	3		7	
Number of male-female pairs	3		7	
Average of pair differences in:				
Daily caloric intake	49		44	
Weekly age	1.3		1.9	
Weight (ounces)	1.2		1.0	
	High Calorie Group	Low Calorie Group	High Calorie Group	Low Calorie Group
Number of different individuals	4	5	10	9
Daily ounce intake	18–27	18–27	24–40	24–30
Daily caloric intake	367–548	305–504	361–528	314–488
Weekly age	3–13	2–10	3–12	3–13
Weight	6 lb 6¼ oz. to 9lb 3 oz.	6lb 7¾ oz. to 9lb 4¾ oz.	6lb 12¼ oz. to 8lb 8½ oz.	6lb 12 oz. to 8lb 9¼ oz.

based on extremely limited data. The results are remarkably consistent considering the few cases upon which the analysis is based. It must be remembered too that differences of great magnitude in sucking scores by the two groups could hardly be expected in this analysis because our subjects were all under thirteen weeks of age, the age at which non-feeding sucking occurs relatively infrequently.

C. SUCKING IN RELATION TO QUALITATIVE DIFFERENCES IN FOOD INTAKE

1. *Sucking Behavior of Comparable Age and Weight Groups Receiving Different Kinds of Formula in the Same Amount*

During a part of the course of this study an experiment was in progress in the institution caring for our subjects to test the effectiveness upon certain aspects of development of enzyme milk, or enzylac (a soft curd milk) (4). In addition to the experimental group of normal healthy infants receiving enzylac, there were two control groups whose formulas included evaporated milk or whole boiled milk. In each case dextro-maltose and water were added to the milk. We shall compare the sucking behavior of groups of infants—all under three months—who were of the same age and were receiving the same liquid volume although different formulas. Sucking scores are based only on observations made during comparable intervals following feeding. Of the twenty-two intervals of one hour's duration during which sucking was observed after the six o'clock meal, there were eight instances in which infants receiving evaporated milk formulas sucked more than those receiving enzyme, while the infants for whom enzyme milk was prescribed had the higher frequency of sucking fourteen times. There appears to be little difference in amount of sucking between the babies getting enzyme milk and whole boiled milk. The infants receiving evaporated milk, however, do seem to show a fairly consistent tendency to suck less than those getting either enzyme or whole boiled milk.

TABLE 13

AMOUNT OF SUCKING BY HIGH AND LOW CALORIE GROUPS AT SUCCESSIVE HOURS AFTER THE MEAL

Hour after Formula	6:00 A.M. Formula Meal					10:00 A.M. Formula Meal				
	Per Cent of Sucking		Critical Ratio*	Number of Observations		Per Cent of Sucking		Critical Ratio*	Number of Observations	
	High Calorie Group	Low Calorie Group		High Calorie Group	Low Calorie Group	High Calorie Group	Low Calorie Group		High Calorie Group	Low Calorie Group
Group Receiving Evaporated Milk Formula										
First						5.9	34.3	−3.16	34	35
Second						32.3	5.6	+2.67	31	18
Third	0.0	0.0	0.0	7	2	16.0	11.1	+ .46	25	18
Fourth	7.7	25.0	−1.92	39	28	33.3	33.3	0.0	9	3
Fifth	13.9	18.2	− .40	36	22					
Sixth	0.0	....	....	3	..					
All Hours	9.4	21.2	−1.84	85	52	19.2	21.6	− .39	99	74
Group Receiving Enzyme Milk Formula										
First						22.8	24.6	− .33	123	126
Second						24.3	25.9	− .27	103	108
Third	29.3	43.4	−1.81	75	76	26.3	27.6	− .21	99	105
Fourth	30.2	36.7	−1.00	106	109	15.4	42.9	−1.66	13	14
Fifth	28.9	55.3	−3.42	76	76					
Sixth	....	50.0	....	...	6					
All Hours	29.6	44.2	−3.44	257	267	24.0	26.6	− .77	338	353

* (+ indicates more sucking by the high calorie group; − by the low.)

While the differences in sucking by our different formula groups are not large, the suggestion of less sucking by infants receiving evaporated milk is not inconsistent with the hypothesis that hunger plays a part in the acquisition of the sucking habit. Roughly supporting this hypothesis is the finding of Fetter and Schlütz (14) of a greater delay in the onset of hunger contractions in five children from seven to fourteen years of age, following a meal of evaporated milk than following meals of several other types of milk. Unfortunately enzyme and whole boiled milk were not included in their list.

Not out of line with our hypothesis, though not crucially supporting it either, are findings by Riesenfeld (44) who compared losses in weight for newborn infants who were exclusively breast fed, with losses for infants receiving supplementary feedings of six different types of food as follows: (1) evaporated milk, water, and dextro-maltose; (2) sodium citrate and beta lactose solution; (3) powdered lactic acid milk with five per cent dextro-maltose; (4) powdered whole milk with five per cent dextro-maltose; (5) standard formula (whole milk, water, dextro-maltose); (6) synthetic milk adapted. The infants receiving the supplementary feedings lost weight with less frequency, and, when they did lose, averaged a smaller loss, than did the exclusively breast fed infants. The supplementary formulas were efficacious for preventing loss of weight in the order mentioned above, with the infants given evaporated milk supplements losing the least weight.

2. *Sucking Behavior of Infants Receiving Acidified Milk*

Three of our infants under thirteen weeks of age were receiving a formula composed of plain lactic acid milk, water, and dextro-maltose. Since hunger contractions have been demonstrated to occur earlier after ingestion of acidified milk than after other milks (28, 38, 46), we thought it might be revealing, even though cases were few and probably selected (and we know individual differences are great), to compare the sucking behavior of these three infants with that of similar age infants (5-12 weeks) who were receiving three other formulas. There was a trend towards higher sucking scores by the infants having acidified milk.

3. *Sucking Behavior of Infants Following Intake of Milk Formula and Following Meals of Cereal or Vegetable*

In scanning our data for clues bearing upon the problem of the influence of qualitative differences in food intake upon sucking, we studied the behavior of the infants subsequent to different kinds of meals. A comparison of the frequency of sucking following the ten o'clock formula, the cereal meal, and the vegetable meals for the same children reveals certain interesting differences which can be perceived readily from the curves of sucking shown in Figures 1 to 13 and also in Figures 22 and 23. In the last two figures we have included sucking scores based on considerably fewer than twenty observations per ten-minute interval, which was the standard held for the inclusion of a statistic in the set of figures named first.

Table 14 lists the amount of sucking as well as the critical ratios between the measures of sucking frequency taken hourly after different meals. To compute each measure the results from all observations made on all children during a given

AGE GROUP 13-16 WEEKS
AGE GROUP 17-20 WEEKS
AGE GROUP 21-24 WEEKS
AGE GROUP 25-28 WEEKS
AGE GROUP 29-32 WEEKS
PERCENT OF OBSERVATIONS IN WHICH SUCKING OCCURRED
TEN-MINUTE INTERVAL AFTER F10
TEN-MINUTE INTERVAL AFTER CEREAL
TEN-MINUTE INTERVAL AFTER VEGETABLE

FIG. 22. Frequency of sucking following the 10 A.M. formula, the cereal, and the vegetable meals for infants of 13-32 weeks.

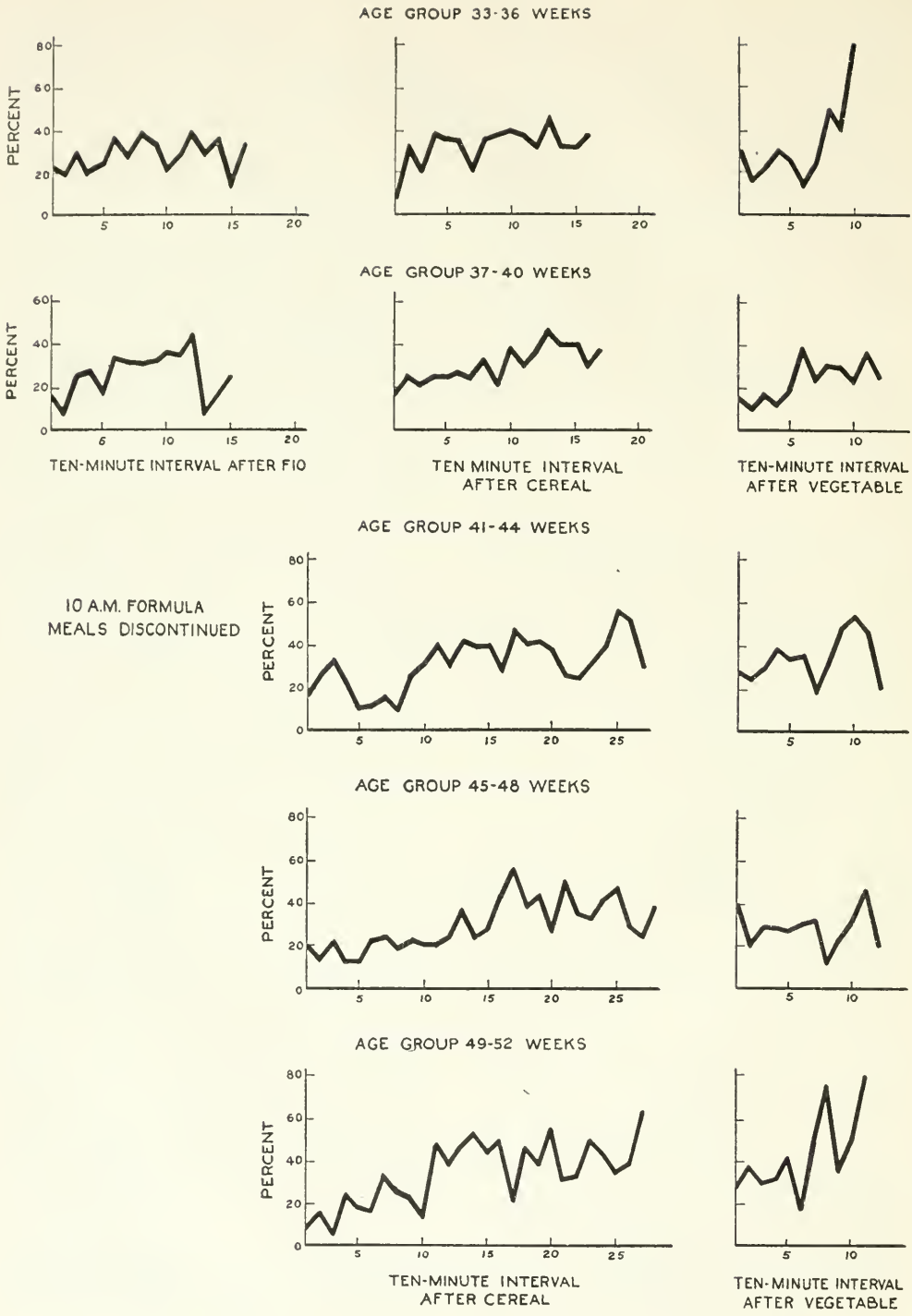

FIG. 23. Frequency of sucking following the 10 A.M. formula, the cereal, and the vegetable meals for infants of 33-52 weeks.

hour following a certain meal were added. Because of the feeding schedules at the institution, we could follow the children for only two hours after the vegetable meal.

We find with remarkable consistency higher sucking scores for comparable intervals after the cereal meal than after the 10 o'clock formula meal. There is only one exception to this trend occurring in the tenth lunar month group. The statistically significant critical ratios are more likely to occur at the younger age levels.

Almost as impressive consistency is found in the frequency with which infants suck more following the vegetable meal than following the milk formula meal. Again the exceptions occur at the older age levels,—namely in the eighth

TABLE 14

AMOUNT OF SUCKING AND CRITICAL RATIOS BETWEEN SUCKING SCORES FOLLOWING THE 10:00 A.M. FORMULA, THE CEREAL AND THE VEGETABLE MEALS

Lunar Month of Age	Hour Succeeding the Meal	Sucking after 10:00 A.M. Formula Meal	Sucking after Cereal Meal	Sucking after Vegetable Meal	Critical Ratios between Sucking Scores after:		
					Cereal* and Formula	Cereal* and Vegetable	Formula and Vegetable**
		%	%	%			
4	First	26.2±2.1	43.2±5.1	....	+3.1	.....	.....
	Second	31.4±2.7	52.5±3.3	....	+4.9	.....	.....
	Third	45.9±3.9	56.4±3.1	....	+2.1	.....	.....
5	First	26.9±2.0	39.1±3.3	36.3± 2.6	+3.2	+ .7	+2.8
	Second	34.0±3.5	42.2±2.3	37.7± 4.8	+2.0	+ .8	+ .6
	Third	45.8±6.5	60.4±2.6	....	+2.1	.....	.....
6	First	31.0±2.0	38.3±2.8	41.4± 2.7	+2.1	− .8	+3.1
	Second	40.8±2.8	44.3±2.3	58.1± 7.5	+1.0	−1.8	+2.2
	Third	20.0±6.8	55.0±2.9	— —	+4.2	—	—
7	First	26.2±2.0	41.5±3.2	36.1± 3.2	+4.0	+1.2	+2.5
	Second	32.7±2.9	33.8±2.3	52.6±11.5	+ .3	−1.6	+1.7
	Third	48.2±6.7	49.6±3.1	— —	+ .2	—	—
8	First	26.8±2.1	34.3±3.6	33.3± 2.9	+1.8	+ .2	+1.8
	Second	31.1±2.8	32.3±2.4	18.6± 6.0	+ .3	+2.1	−1.9
	Third	40.4±6.8	45.6±3.1	....	+ .7	.....	.....
9	First	23.5±2.4	29.2±3.5	23.4± 2.7	+1.1	+1.3	− .03
	Second	30.8±3.3	35.4±2.7	39.1± 6.1	+1.1	− .6	+1.2
	Third	28.3±6.6	37.5±3.4	....	+1.2	.....	.....
10	First	19.2±2.7	23.9±3.7	18.0± 2.3	+1.0	+1.3	− .3
	Second	34.8±4.1	31.2±3.1	27.6± 4.1	− .7	+ .7	−1.2
	Third	10.0±5.5	39.2±3.7	....	+4.4	.....	.....
11	First	....	19.3±3.8	31.2± 2.8	.....	−2.5	.....
	Second	....	26.8±3.1	34.9± 4.6	.....	−1.5	.....
12	First	....	17.4±3.0	29.0± 2.7	.....	−2.9	.....
	Second	....	21.8±2.7	27.0± 4.0	.....	−1.1	.....
13	First	....	15.1±3.5	31.1± 3.8	.....	−3.1	.....
	Second	....	30.8±4.1	57.1± 7.1	.....	−3.2	.....

* (+ indicates more sucking after cereal.)
** (+ indicates more sucking after vegetable.)

and tenth lunar month groups. It is not surprising that we see exceptions to an otherwise consistent trend occurring at these ages immediately preceding the end of the bottle regimen. The eight to ten month old children ate relatively more solid foods than the younger and it is possible that the formula meal, consisting as it did of a liquid food only, was no longer particularly effective in staving off hunger.

No consistent differences appear in amount of sucking observed in periods following cereal and vegetable meals.

One might expect less hunger with consequently less sucking after a meal of cooked cereal than after the milk formula meal, if there is a relationship between hunger and sucking, because liquid foods, generally speaking, leave the stomach more rapidly than do solid foods. However, there probably are reasons why in our data this expected relationship does not appear. For instance, a very small amount of cereal was given the babies at first. The initiation of cereal feeding occurred when the babies were three months old. On the first day only one teaspoon of cereal was offered and this amount was increased one teaspoon daily until one ounce was given. After this point, the amount was increased one tablespoon daily until four to six ounces were offered at a feeding. This means that the amount of cereal *offered* reached a maximum at about a month to a month and a half after the food was first presented. The amount of cereal provided the older infants at eight o'clock in the morning was limited to a fixed quantity, as just described, lest it interfere with the baby's appetite for the ensuing milk meal at ten o'clock. The amount of milk formula given was increased as the child advanced in age and seemed to be regularly consuming his full quota, up to thirty-two ounces a day, after which, if the infant had reached seventeen pounds in weight, he was placed on a three meal a day schedule with as much milk by the cup as he desired. We found, too, that some children did not like cereal and ate little or none, another reason for the relatively frequent sucking following the cereal meal.

Unfortunately, too, we cannot estimate the caloric value of the cereal meal because we recorded neither the amount of cereal ingested nor the specific kind of cereal served.

Thirdly, in the case of the older children (8-9 months), we suspect that the frequency of sucking following the cereal meal might have been influenced by variables other than the nature of the food eaten, namely, the other features of the child's routine that we could not keep constant, such as the play situation he was placed in. This was discussed more fully on pages 36 to 40.

The same arguments that we used to explain the greater frequency of sucking after the cereal meal than after the formula meal apply also to our second finding of more sucking after the vegetable meal than after formula. Like cereals, the vegetables were at first given in very small quantities which were gradually increased to a maximum portion of two ounces of vegetables plus two ounces of mashed potatoes. Individual differences, too, were found with respect to likes and dislikes for vegetables, and it was noted that not all children consumed the entire serving.

From the standpoint of the quantity and the solidity of food consumed, there was not much difference between the cereal and vegetable meals as they were served in the institution in which we

made our observations. It is not surprising, then, that our infants show no regular pattern of sucking trend subsequent to these two meals. However, the rather consistent tendency of the babies to suck more after a vegetable meal than after a cereal at ages eleven to thirteen lunar months may have come about, in part at least, because of hospital routines to which the infants were subjected. These age groups are the only ones who omitted the ten o'clock formula meal. Because the cereal meal was the first meal of the day its administration was the first task of the new shift of nurses who came on duty at 7:00 A.M. It often happened that cereal feeding was completed, rather than just beginning, well before eight o'clock in the morning. On the other hand, the vegetable meal, though scheduled for noon, rather frequently occurred late because of unavoidable interruptions of the morning baths and medical examinations. This tendency for cereal feeding to occur a bit ahead of schedule and for vegetable feeding to be late meant frequently an interval of five hours rather than of four between feedings for some children. This suggests the possibility that a vegetable meal planned to allay hunger after a four-hour interval was inadequate for satisfaction after five hours. Unfortunately, here, too, we are not in a position to relate the caloric value of the cereal and vegetable meals.

Perhaps a finding by Maile and Scott (34) is pertinent here. In a study of the digestibility of certain common foods by adults, these investigators found that after certain types of meals—for example, after a meal of potatoes only—the subject became ravenously hungry long before the stomach was empty. As mentioned previously, the vegetable meal for our subjects consisted always of equal quantities of mashed potatoes and of one other vegetable. We know of no data that would throw light on the relative digestibility of milk, cereal, and vegetables served our young subjects.

D. SUCKING FREQUENCY IN RELATION TO AGE

Figure 24 and Table 15 show the average sucking scores of our subjects for each lunar month of age.

Each point on the charts has been computed on the basis of all available data. It should be made clear, however, that successive points on the curves do not represent the mean scores of the same group of infants. Some infants may be represented in only one or two averages. Data pertaining to other infants may be included in the averages for six successive lunar months. Table 15 reveals that the mean sucking scores for some age groups have been determined on the basis of a greater number of observations and on a greater number of subjects than the scores at other ages.

The frequency of sucking on the part of our infants taken as a group seemed to increase rapidly during the first three months and then to run along on more or less of a plateau for a few months, after which it gradually declined before rising again during the last three months of the year. Whether the rise in the averages for the last months accurately describes the usual sucking trend among infants, or is merely an artifact arising from the selection of cases, is a question. However, the consistency of the increase in the early months, together with the similarity in pattern shown by these data and the data of our preliminary study, make us feel that this initial rise at least is not merely a function of selective influences.

How can we account for this increase in sucking with age up to 12-16 weeks? When one observes thumb- and finger-sucking by very young infants one is impressed by the apparently accidental manner in which the digit first finds its way into the mouth. The impression that the insertion of the digit is accidental is strengthened by the observation of the momentary duration of sucking by young infants in contrast to more prolonged sucking by older babies. If the finger-sucking act occurs frequently enough, it may become conditioned to the sensations accompanying response to the bottle, and may soon occur as a response to a need. If one thinks of conditioning not merely as a function of simultaneous exposure to conditioned and conditioning stimuli, but also as a function of motivation or need, then we should expect infants in a state favorable to the intake of food to take to finger-sucking more readily than those less motivated. It is in order to recall here Watson's and Jensen's observations that the satiated child does not suck readily or prolongedly. As the infant develops strength and more control over his members he is more capable of increasing the frequency and duration of sucking and the act may thus become habitual. It is interesting in this connection also that the amount of sleep an infant indulges in decreases as he grows older and that young infants up to the age of about sixteen weeks do a greater proportion of their sucking while they are awake than do older infants, a fact which suggests that the control factor is one of importance. It is possible as well that as the young infant spends more time awake he becomes more in need of activity and may indulge in thumb-sucking for lack of something else to do. His mouth is an organ for exploration.

A study of Gesell's (16, 17) developmental norms for infant behavior may

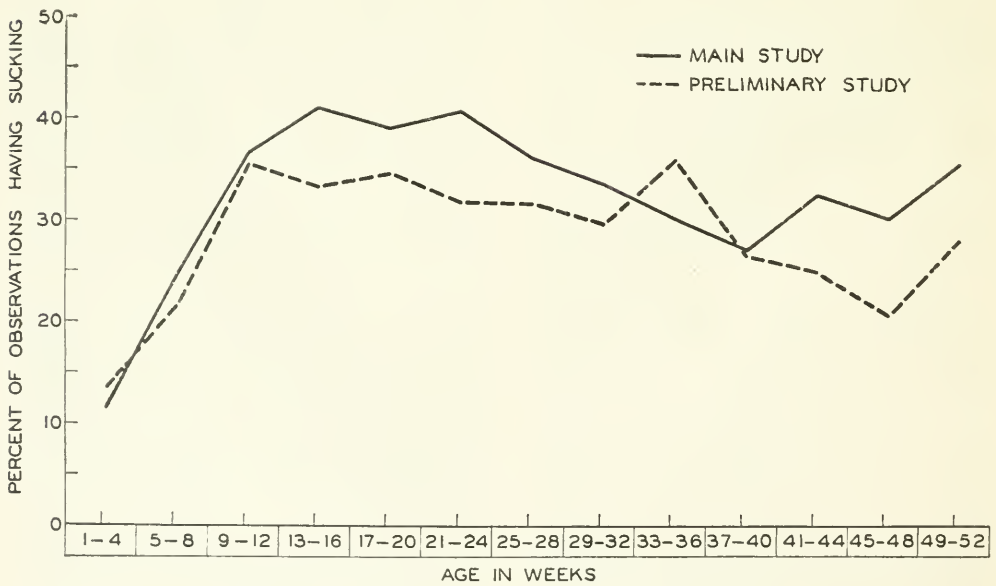

FIG. 24. Average sucking score for each four-week group.

throw some light on the declining trend in sucking between the ages of about twenty-four to thirty-eight weeks. In many ways the period around twenty-four weeks can be considered crucial in the child's development. His arms now have their full extension and he is consequently enabled to touch a wider range of objects including parts of his own body such as the knees. He can now lift his head when in the prone position and rest his weight on his extended arms. He can regard objects for a fairly prolonged period, and above all he is improving markedly in the power to manipulate objects. While then at the early ages sucking is one activity open to the child from his very limited repertoire of activities, development in ability to use his hands and to regard the surrounding environment more discriminatingly necessarily widens his horizon and competes with internal stimulation and thumb-sucking for his attention.

The final rise at the end of the first year of life in the curve of sucking for our group, which, on the basis of the exposition just given, one would not expect, may still be reconciled with the known facts of developmental behavior of infants, when the unique environment in which our subjects developed is considered. At approximately thirty-eight to forty weeks the infant normally tends to acquire certain abilities leading directly to walking. He attains the sitting position and soon thereafter tends to propel himself forward and to creep. He tends also to learn to stand by supporting himself on the rail of his bed. Since our infants had less opportunity to indulge in these normal explorations than do most babies reared in their own homes, they may have felt thwarted. They may have felt the urge to move about, but by being confined to the narrow limits of their beds, except for a brief period each day when they were permitted to play on the floor, these inclinations could not be put into action. Consistent with this hy-

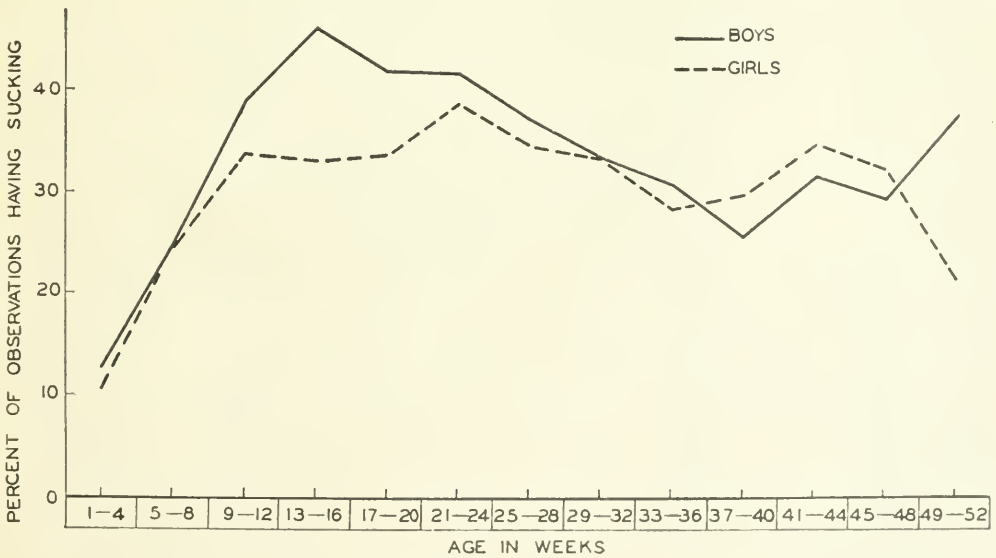

FIG. 25. Sex differences in sucking.

pothesis is our finding that the frequency of sucking drops considerably when the infants are playing on the floor.

It is probably significant also that the age at which sucking begins to increase again coincides with the time of weaning the infant from the bottle. It seems to us that the weaning process might affect the sucking habit in a variety of ways. First, the change from a formula meal every four hours to three meals in every twenty-four hours means less opportunity for the infants to see the attendants and hence less interesting occupation, for meal time affords the main opportunity for play between nurse and infant in the busy routine of an institution. In support of this hypothesis we have demonstrated that sucking is reduced when attendants are present in the room. Second, the weaning process, with the accompanying lengthening of the intervals between meals, may increase the tendency to suck because of the increase in the duration of the interval in which the child experiences hunger. This hypothesis assumes that the larger spacing between meals is not adequately compensated for by the greater relative intake of food at a meal. Consistent with this hypothesis is our

TABLE 15

AVERAGE SUCKING SCORES FOR EACH LUNAR MONTH OF AGE

Age of Subjects in Weeks	Number of Observations	Number of Weekly Records	Number of Subjects	Average Sucking Score (Per Cent)	σ_p*
Data from Main Study					
1– 4	1397	35	17	11.3	.9
5– 8	4372	92	34	24.5	.7
9–12	3563	90	37	36.3	.9
13–16	2361	86	48	40.9	1.1
17–20	2653	106	49	38.9	1.0
21–24	2602	113	53	40.3	1.0
25–28	2143	93	44	35.9	1.1
29–32	2102	96	46	33.3	1.1
33–36	1672	72	31	30.0	1.2
37–40	1544	61	26	27.0	1.2
41–44	1444	58	24	32.3	1.3
45–48	1564	55	19	30.1	1.2
49–52	800	27	14	35.4	1.7
Data from Preliminary Study					
1– 4	1059	45	31	13.6	1.1
5– 8	1455	68	37	21.3	1.1
9–12	1118	49	26	35.2	1.5
13–16	1316	61	31	33.1	1.3
17–20	1370	54	27	34.5	1.3
21–24	715	32	15	31.7	1.8
25–28	794	32	16	31.5	1.7
29–32	633	23	11	29.5	1.9
33–36	450	19	9	35.8	2.3
37–40	900	30	11	26.4	1.5
41–44	413	20	10	24.9	2.2
45–48	478	19	9	20.7	1.9
49–52	432	19	6	28.0	2.2

* $\sigma_p = \sqrt{\frac{pq}{n}}$

finding that as the interval elapsing since the last feeding increases, sucking in a group of infants increases. Third, the weaning process may mean a withdrawal of opportunity to suck, for which the infant compensates by sucking on his fingers. This factor, consistent with Levy's hypothesis that infants have a need to suck, was not explored in the present study.

It is possible that teething had some influence upon the rise in sucking practice at the end of the first year. We shall show on pages 58-60 that while the differences in degree of sucking are not large, the trend is consistently in the direction of more sucking by teething than by non-teething infants.

We have already allowed for the possibility that the sucking trend we find at these later months may be due to the nature of our selection of subjects. First, the sucking score of the older groups is weighted by scores of male infants who, we shall show, tend to suck more than girl infants. Second, in the light of the fact that there is a greater demand for girls for adoption, those female infants who still remain in the institution at the end of the first year may be less adoptable because they are physically unstable or because they have been exposed to numerous unfavorable influences affecting development even before entering the institution. Such influences may tend also to increase the frequency of sucking. Actually, one or two of our girls in each group from 39-47 weeks of age sucked at a much higher frequency than the group mean. Our third hypothesis is that since there is a tendency for the children at the upper ages to have been in the institution longer than those at the younger age levels, this greater exposure to a limiting environment and the frustration implied may act to increase the sucking habit.

E. SEX DIFFERENCES IN FREQUENCY OF SUCKING

Figure 25 shows the amount of sucking done by the boys and by the girls. The boys have a higher sucking score at all ages except from thirty-seven to forty-eight weeks, but even here the differences in favor of the girls are not significant. The only differences which yield a critical ratio as large as three are those in favor of the boys at ages nine to twenty weeks, and at forty-nine to fifty-two weeks. Table 16 presents the data summarized in Figure 25. The standard errors of the proportions are computed on the basis of the number of short samples of sucking behavior.

While the average sucking scores for four-week groups for the boys are not much higher than the scores for the girls at most ages, the consistency with which the boys' scores are the higher takes on significance. The three groups, moreover, for which the girls' scores are higher, namely those in the area from thirty-seven to forty-eight weeks, are groups in which the number of female subjects was relatively low.

Our findings concerning sex differences in sucking raise an interesting question relative to differences in metabolic rate of the sexes with perhaps accompanying differences in degree of hunger. There is evidence that the basal metabolic rate of boys at the pre-school level and later, and of adult males (13, 33, 45), tends to be higher than that of females, yet Benedict and Talbot (2), in a study including measures of metabolic rate in infants as well as in older children, found no sex differences in metabolic rate until the infants attained eleven kilograms of

weight. Benedict and Talbot's subjects of this weight ranged in age from ten and one-half months to two years and one month, but the majority were between a year and a half and two years of age. In the case of their subjects of eleven kilograms and over, there was a tendency for boys to have a somewhat higher metabolism than girls of the same weight or of the same area of body surface. Believing the Benedict and Talbot data none too convincing because of the limited number of different infants on whom their measures were based, we have looked to the studies on sex differences in activity for clues, for we know that bodily activity is likely to raise the basal metabolic rate. It is often suggested that boy infants are more active than girl babies, and Richards (40) did find this to be true to a small extent of the neonate. We have not encountered evidence to substantiate this difference for older infants.

Another possible explanation of the higher frequencies of sucking by our male infants is the fact which we pointed out above, that in all age groups after that of nine to twelve weeks the infants who have been in the institution longest are the boys. This is due to the greater demand for girl babies for adoption, and it may well be that longer residence in an orphanage is conducive to increased sucking.

F. SUCKING IN RELATION TO TEETHING

The teething process suggested itself to us as a variable that might influence sucking at certain ages. It was surprising to us to find, then, at the ages at which teething was beginning or in full swing (21-38 weeks), a gradual decline in mean and median sucking frequency. As shown in Figure 24, there seemed to be a tendency for sucking to increase in the period from 37-52 weeks, but with the exception of the last four weeks, the proportion of daily records on teething children included at each age is no higher than it is between the ages of 29-38 weeks. At 25-28 weeks the teething infants equal in number those not teething. Under twenty-five weeks of age there are fewer

TABLE 16

SEX DIFFERENCES IN SUCKING

Age of Subjects in Weeks	Sucking Score in Per Cent		Critical Ratio*	Number of Weekly Records		Number of Different Subjects	
	Boys	Girls		Boys	Girls	Boys	Girls
	Mean σ	Mean σ					
1– 4	12.5±1.4	10.3±1.1	+1.2	16	19	8	9
5– 8	24.6±1.0	24.4± .9	+ .2	43	49	16	18
9–12	38.7±1.2	33.7±1.2	+2.9	45	45	20	17
13–16	45.9±1.4	32.9±1.6	+6.2	49	37	26	22
17–20	41.8±1.2	33.5±1.6	+4.2	73	33	32	17
21–24	41.6±1.3	38.4±1.5	+1.6	67	46	32	21
25–28	37.0±1.5	34.6±1.6	+1.1	51	42	26	18
29–32	33.4±1.3	33.2±1.8	+ .1	62	34	30	16
33–36	30.9±1.5	28.2±1.9	+1.1	47	25	21	10
37–40	25.8±1.4	29.8±2.2	−1.5	44	17	19	7
41–44	31.6±1.4	34.8±2.7	−1.1	44	14	16	8
45–48	29.6±1.3	32.2±2.9	− .8	46	9	15	4
49–52	37.9±1.9	21.6±3.8	+3.9	23	4	12	2

* (+ indicates more sucking by the boys.)

children teething than not teething.

All diagnoses of the teething condition were made by the observer. She recorded the number of teeth each infant had, the presence of swollen gums, and the number of teeth cutting through. These data were recorded once each week for each child who had begun to teeth, on the same day that he was observed for sucking. Examination of the teething condition on any one day was always made without reference to the previous teething records. After completing the mouth examinations, the examiner compared her records with those of the previous week. If the day's report of a child seemed to be discrepant with the previous report or with the development logically expected, a re-examination was made of that particular child. This procedure afforded an excellent check on the accuracy of the teething diagnoses. It is unlikely that the observer would be influenced in her judgment of a particular case by her memory of the notations she made the week before, since at least sixty other infants would have been examined in the interim of a week.

Two types of analysis were made to throw into relief the relationship between sucking and teething. It is of interest to know whether a group of infants who are teething indulge in sucking to a greater extent than a group of infants of the same age who are not yet teething. Of even greater interest is the trend of sucking from the pre-teething to teething stage in the individual child. We have therefore analyzed the data with respect to these relationships between sucking and teething in both individuals and groups of infants.

1. *Group Comparisons*

The infants at each lunar month age level were divided into groups on the basis of teething condition, i.e., those who were teething and those who were not. Table 17 presents the sucking data for these two groups. While the differences are statistically significant for only two age groups, the teethers suck slightly more than the non-teethers in all but the youngest group. The standard errors used in determining the critical ratios are based upon number of observations.

Our data seem to lend some support to the idea that sex influences may be

TABLE 17

FREQUENCY OF SUCKING FOR TEETHING AND NON-TEETHING INFANTS

Age of Subjects in Weeks	Teething Infant			Non-Teething Infants			Critical Ratio*
	Average Sucking Score (Per Cent)	Number of Observations	Number of Individual Children	Average Sucking Score (Per (Cent)	Number of Observations	Number of Individual Children	
17–20	32.0	150	6	39.0	2228	50	+1.77
21–24	42.3	426	12	40.5	2037	46	+ .66
25–28	36.1	905	27	35.3	1158	28	+ .37
29–32	34.7	1465	35	26.9	457	15	+3.16
33–36	30.5	1250	31	30.1	346	10	+ .14
37–40	27.3	1075	25	26.8	452	9	+ .19
41–44	34.7	852	24	31.4	487	12	+1.19
45–48	30.8	997	21	28.7	567	9	+ .84
49–52	37.8	746	15	15.1	86	2	+5.28

* (+ indicates more sucking by teething infants.)

operating to cloud the question of the relation between sucking and teething since for all but the two oldest age groups, the boys, who it must be remembered tend to suck more than girls, are in a higher proportion to the total number of children in the group in the case of the teethers than in the case of the non-teethers.

2. *Individual Analysis on the Basis of Adjusted Scores*

A further exploration of a possible relationship between the variables under discussion was made by controlling interval after feeding before determining the sucking score for each child. That is, the daily sucking scores for any given child were computed on the basis of the same range of intervals after the same meals. In addition to this change in the method of computing the score, different comparisons were made. Instead of averaging together the data for a number of weeks to obtain one median score, comparisons were now made only from one week to the next. For example, the average sucking score for a week of no teething activity, for a particular subject, was compared with his average sucking score for the following week during which he was teething. Sucking during an ensuing quiescent week was in turn compared to the average sucking score of the immediately preceding week of teething.

There were nineteen instances of increased sucking and twenty instances of decreased sucking during a week of teething as compared with a preceding week in which no teething activity occurred.

There were eight cases of increased sucking and five of decreased sucking during a week of no teething activity, compared with a preceding week of teething.

These data, which seem not to establish a relationship between the teething process and thumb- or finger-sucking, are undoubtedly influenced by many subtle factors that were not measured in this study. Perhaps some children, during a week of teething, experienced sufficient general bodily distress to cause a decrease in food intake. The following week, bringing relief from teething, may have brought in addition increased hunger and more sucking.

We remind the reader that our definition of sucking given on page 10 does not include biting. It may well be that the frequency of biting fingers and other objects does increase during teething, and that the commonly held belief to the effect that sucking habits increase during teething is due to a failure to differentiate between sucking and biting.

Another consideration occurs to us to explain the low degree of relationship between frequency of sucking and the teething process. The state of "cutting" a tooth, which we considered a phase of the teething process, instead of being experienced as pain by the infant might actually mean to him a release of tension. If this were true for a number of infants the data for "teethers" would include observations made subsequent to the existence of teething tensions. It must be kept in mind also that numbers of cases, as well as observations basic to any score, are few.

G. SUCKING IN RELATION TO UNLABELLED INDIVIDUAL DIFFERENCES

It is of considerable importance to study the trend in sucking practice in the individual child. Does almost every infant conform in his development to the pattern revealed by the curve based on group averages? Are individual patterns

interpretable in terms of known happenings?

The course of sucking practice was charted for each child as long as he was available for observation, the scores for successive weeks being the units in terms of which the developmental changes were set forth. For younger infants the week's score is based generally on the average of two or three separate days of observation, while for older infants the majority of weekly scores are computed on the basis of only one day's observations. Since the length of interval between the observation period and the time the child was last fed is an item with which the frequency of sucking varies, only those scores for a given child are compared which are based on the same range of time after a given one or more of the daily meals. It should be made clear that the content of the meals and the interval between feedings vary with the individual child but a definite schedule of formula and feeding interval was adhered to for each infant until his development or health dictated a change. The details of the feeding routine in the institution for infants of various ages were set forth on page 8.

In order to control the influence in our data of the factor of time between the observed period and feeding we had to omit some of our data. This accounts for the gaps in some of the curves and doubtless reduces the reliability of our measures. Some of the more complete curves are presented in Figures 26 to 29. Unfortunately most of the curves cover only a few weeks. The curves in Figure 26 are for those of our subjects who were in the institution from one to twenty-five weeks of age; in Figure 27, for subjects of ten to thirty-five weeks of age; in Figure 28, for infants from fifteen to forty weeks; and in Figure 29, for babies whose stay in the institution covered from about thirty to fifty-two weeks of age.

The most consistent trend in the individual curves is an increase in sucking frequency during the early weeks of life. The age at which the maximal amount of sucking occurs, according to our somewhat unreliable measures, varies and the curves are rather irregular, but it can be said that the majority of infants show an increasing tendency to suck with age during the first three to four months of life.

The gradual leveling off in sucking from twenty-one to thirty-eight weeks seen in the composite curve is not so consistently found in the individual curves. Most of the curves are irregularly peaked, the fluctuations in sucking from week to week being rather large.

The majority of infants in the highest age group do show an upward trend in sucking but even here the individual patterns are varied. Such variety in the individual patterns suggests that sucking behavior is sensitive to many influences.

Several statements might be made to characterize the sucking habits of individual infants. Every one of the 143 individuals observed in this study sucked his thumb or finger to some degree. The days when the sucking score was zero for any infant were few, and no infant maintained a zero score for all the days on which he was observed. The daily individual sucking scores ranged from zero to ninety-six per cent. But indulgence in sucking cannot be thought of as a result of entirely incidental and ephemeral factors. By far the majority of infants tended to suck at characteristic levels of frequency for several weeks at a time. The fluctuations in average sucking score from

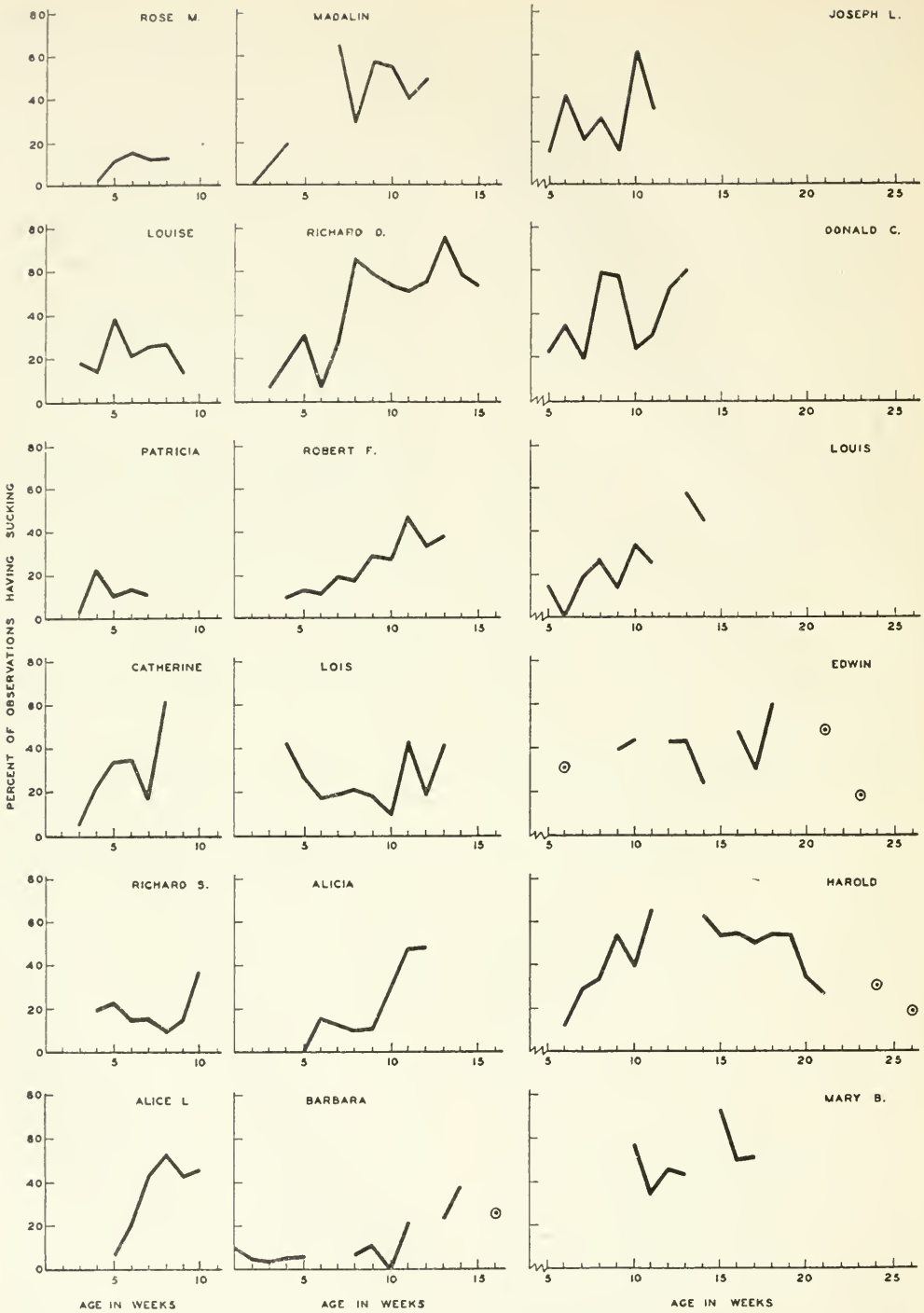

FIG. 26. Individual age trends in sucking.

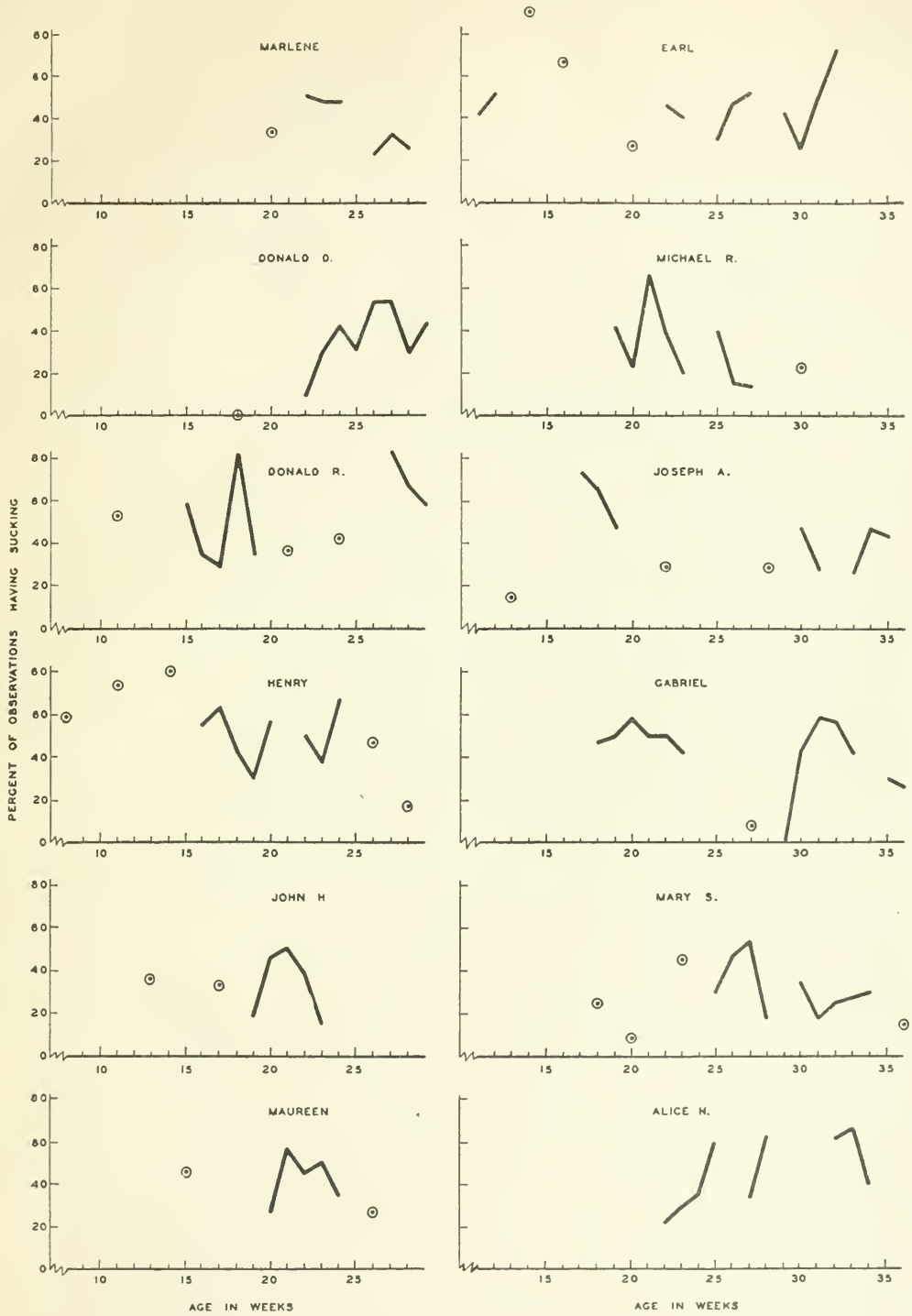

FIG. 27. Individual age trends in sucking.

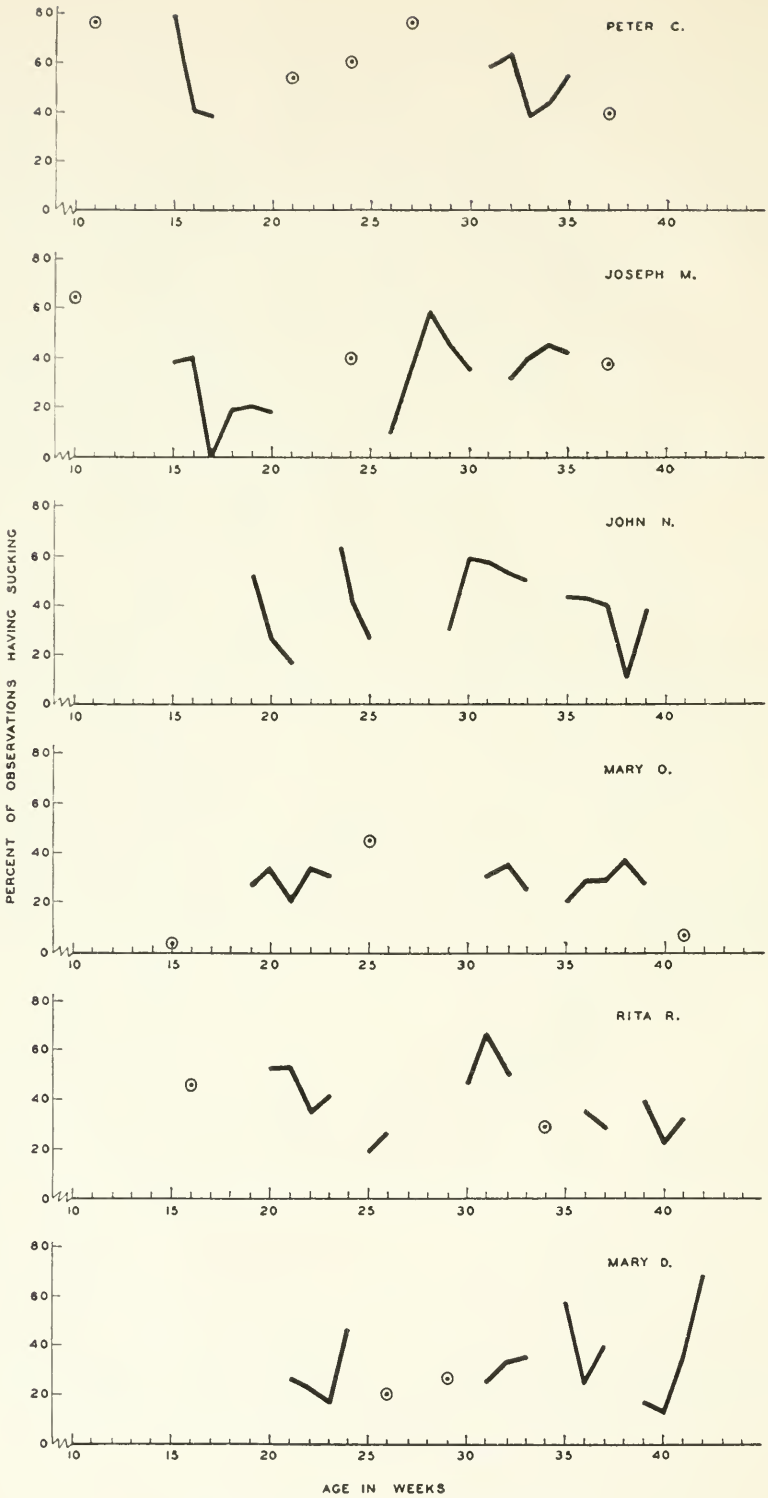

FIG. 28. Individual age trends in sucking.

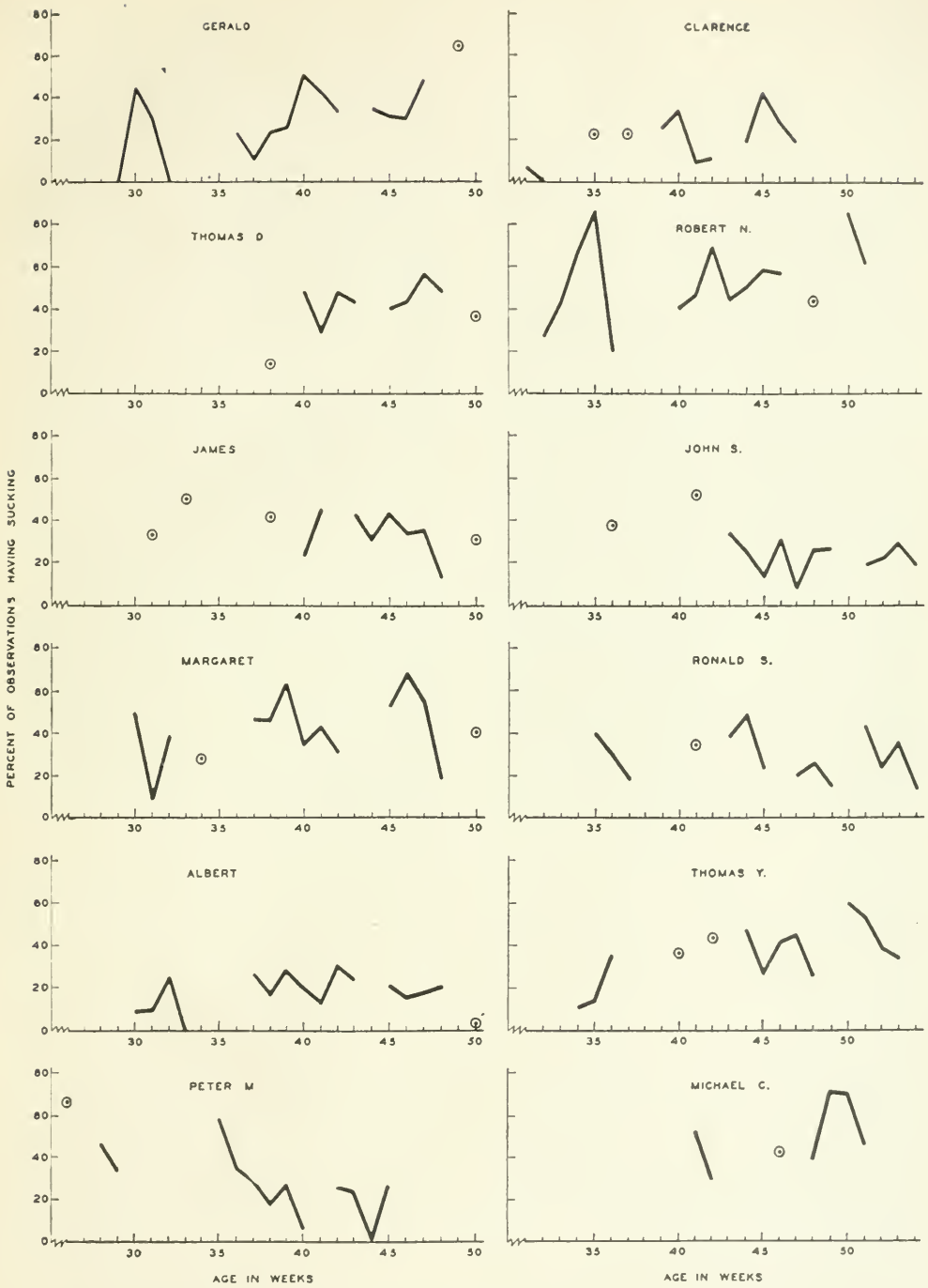

FIG. 29. Individual age trends in sucking.

week to week were not large enough to obscure long-time trends of increase or decrease in the habit. The general pattern of sucking practice varied a good deal from infant to infant, the only characteristic common to a great number of infants being the increase in sucking during the early weeks of life.

Although the data discussed in the previous paragraphs agree with those of other investigators in suggesting that thumb- and finger-sucking must be considered a normal phenomenon of infancy, we still have the problem of explaining the wide range of individual differences in sucking habits. Moreover, even though we have demonstrated that the average sucking frequency of groups of infants is reduced by such influences as the number of attendants in the room, or the location of the infants in an environment other than their beds, or the body position of the infant, these can hardly be considered the major determiners of individual differences in sucking habits in our subjects since these influences extended usually simultaneously to a large number of infants. It seems more likely, then, that the individual differences observed stemmed more from differences in intra-organic condition or emotional need than from differences within the external environment.

We have demonstrated also that sucking frequency increased in groups of infants under certain circumstances favorable to hunger. Inasmuch as we have no measure of hunger in the individual child we cannot establish a correlation between individual differences in the degree of hunger and individual differences in the sucking habit, but because we know that individual differences do exist in the rate of gastro-intestinal motility and because our data establish that groups of infants suck more frequently when they are probably hungry, we suggest the hypothesis that differences in the rate and vigor of gastro-intestinal motility, with all that lies in back of this in the way of physico-chemical and emotional conditions, may be very important determiners of individual differences in the sucking habit.

V. General Summary and Interpretation of the Study

Thumb- and finger-sucking habits in young infants were studied primarily in relation to the variable of hunger, though also in relation to age, sex, teething condition, location and body position of the child, and the number of adults working in the room while the child was observed. Finally, individual differences in sucking trends were also analyzed.

Analyses are based upon 28,000 short-samples of the behavior of 143 infants in the first year of life. All babies studied were charges of one orphanage and, as such, were subject to relatively similar routines.

The major findings are as follows:

1. Sucking-frequency increased as time elapsed after feeding, whether the infants were asleep or awake. The increase in frequency of sucking was particularly noticeable in the period beginning an hour and a half to two hours after a meal, the time when the "hunger" contractions begin to gain momentum.

2. The amount of sucking correlated positively with the liquid volume of the formula taken by the infant when age and weight of the infant were controlled. This observation suggests that babies seeming to need formula in excess of adopted standards may be infants who experience the more vigorous hunger contractions.

3. The amount of sucking correlated negatively with the caloric value of the formula consumed, when the controls included the volume of formula consumed and the age, weight, and sex of the infant.

4. Little difference was noted in the amount of sucking done by infants receiving enzyme and whole boiled milk formulas, but infants getting evaporated milk did show a tendency to suck less than infants for whom the other two formulas were prescribed. Three of our infants receiving acidified milk formulas were more prone to suck than infants on other types of milk. These findings are in agreement with the hypothesis that hunger plays a role in the acquisition of the thumb-sucking habit, since other investigators have presented evidence to show that hunger is delayed longer after ingestion of evaporated milk than after other milks, as well as evidence that hunger contractions occur earlier after a meal of acidified milk than after other milks.

5. Most of the infants studied began to suck their thumbs or fingers to a small degree very soon after birth and increased the frequency of their sucking quite rapidly during the first three months of life. Group data show a plateau in sucking frequency from the third through the sixth lunar month, then a decline to the tenth month, followed by a rise in the last weeks of the year. The hypothesis has been offered that increase in the frequency of sucking soon after birth may be due in part to improvement in muscular strength and coördination. It is unlikely, however, that frequent accidental insertions of the thumb into the mouth would lead to a habit of thumb-sucking if the practice were not uniquely satisfying because of internal conditions in the child. The early rise in sucking frequency may also be a reflection of the decrease in the amount of time the infant spends in sleep, since sucking is one of the few activities open to the young infant, and since the young infant sucks more frequently during his waking hours. It should not be surprising that sucking frequency decreases after twenty-four weeks of age—the time when manipula-

tion and concentration improve markedly. The fact that our oldest subjects sucked more on the average than did our somewhat younger infants may have been due to (1) weaning, (2) frustration of the infants at being confined to bed for large periods of the day at a time when interest in walking was developing, and (3) selective influences making for an unrepresentative sample of subjects in the highest age groups.

6. Our boy subjects sucked their thumbs with greater frequency than did the girls. This fact seems congruent with the hypothesis that hunger is related to sucking, since there is some evidence that boys have the higher metabolic rate and may consequently experience hunger to a greater degree than do girls. Another factor to be considered, however, is length of residence in the orphanage, since our boy subjects in most age groups had been in the institution longer than the girls.

7. Group results indicated a fairly consistent trend toward more sucking by teething infants than non-teething, though the differences were rather slight and for the most part not statistically significant.

Individual results in relation to teething were less consistent than group results. In these analyses of individual performance, an infant's sucking score during a week of teething was compared with his own score during the preceding week of no teething activity. Under these conditions of observation, a low degree of relationship was found between sucking and teething.

8. There was a decrease in sucking frequency when infants were in a more stimulating situation than being in bed—for example, when playing on the floor. This relationship was given due weight in establishing the correlation between sucking and hunger.

9. Young infants from birth to five lunar months of age did relatively more sucking while they were in the prone position than when supine. This finding was related to evidence on the facilitation of stomach motility by the prone position.

10. Beginning at ages thirteen to sixteen weeks, infants tended to be distracted from sucking when attendants were in the room. The data suggest a low negative correlation between these two variables.

11. Every individual observed as a subject in this study sucked his thumb or finger to some degree. There was a wide range of difference in the degree of sucking manifested by individuals.

We cannot emphasize too strongly that our data pertain to institution babies who do not ordinarily experience the attention that is usually given to infants in their own homes. Our results do not preclude the interpretation that sucking may be an emotional response to a frustration other than food lack. Indeed it is difficult to analyze minutely the various sorts of meanings that hunger might have for an infant. In an institution there is necessarily more interference with the feeding schedule of an infant than is found in better homes, as well as less opportunity to cater to individual rhythms of hunger. It is likely that an institution baby whose organic satisfactions are delayed repeatedly will come to lack confidence in his environment and will feel more concern, anticipated and immediate, over such physical distress as occurs in periods of intense hunger. The sucking habit may be the child's response to a feeling of deprivation of other things than food.

Furthermore, it is not at all out of the bounds of possibility that some of our subjects, especially those infants who were exposed to adverse circumstances during prenatal life and before entering the institution, were suffering from specific food deficiencies. There is increasing evidence that an organism responds in various ways to such specific food-lacks.

It is not difficult to understand why an infant would choose the sucking act in his search for the fulfillment of a need. He has had ample opportunity to experience satisfaction by sucking during the feeding act. With his satisfaction of hunger while sucking he may associate also satisfaction of his need for human contact, which brings such comforts as dryness, warmth, change of tiring position, and, as he grows older, the many pleasures of social stimulation. It seems entirely reasonable that a child who frequently experiences intense hunger or deprivation of other kinds, or both, will be much more likely to fall back upon thumb-sucking as a compensatory satisfaction. Such sucking readily increases in frequency and becomes a habit.

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